



## **Software Configuration Guide, Cisco IOS XE Denali 16.3.x (Catalyst 3850 Switches)**

**First Published:** 2016-08-03

**Last Modified:** 2018-03-02

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PART **I**

## Audio Video Bridging

- [Audio Video Bridging, on page 1](#)





# CHAPTER 1

## Audio Video Bridging

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- [Introduction to Audio Video Bridging Networks, on page 1](#)
- [Configuring the AVB Network, on page 7](#)
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## Introduction to Audio Video Bridging Networks

### Information about Audio Video Bridging (AVB)

Audio and video equipment deployments have traditionally been analog single-purpose point-to-point one-way links. Migration to digital transmission also continued to retain the point-to-point one-way links architecture. The dedicated connection model resulted in a mass of cabling in professional and consumer applications, which was hard to manage and operate.

In order to accelerate the adoption to Ethernet based audio/video deployments in an interoperable way IEEE came up with the IEEE Audio Video Bridging standards - IEEE 802.1BA. This defines a mechanism where endpoints and the network will function as a whole to enable high quality A/V streaming across consumer applications to professional audio-video over an Ethernet infrastructure.



---

**Note**

- AVB is not supported on stacked systems.
  - AVB is not supported on Etherchannel interfaces.
  - AVB is supported only on STP-enabled network.
- 

### Licenses Supporting AVB

AVB is supported on the following two license levels only:

- ipbase
- ipservices

## Benefits of AVB

AVB is a standard based mechanism to enable Ethernet based audio-video transmission which has the following benefits:

- Guaranteed max Latency
- Synchronized Time
- Guaranteed Bandwidth
- Professional Grade

## Components of AVB Network

AVB protocols operate only in domains where every device is AVB capable. The AVB network comprises of the AVB talkers, AVB listeners, AVB switches and the grandmaster clock source.

- AVB Talker - An AVB end station that is the source or producer of a stream, i.e. microphones, video camera, and so on.
- AVB Listener - An AVB end station that is the destination or consumer of a stream, i.e. speaker, video screen, and so on.
- AVB Switch - An Ethernet switch that complies with IEEE802.1 AVB standards.
- AVB stream: A data stream associated with a stream reservation compliant with the Stream Reservation Protocol (SRP).



---

**Note** In some instances, the word “bridge” is used. In this context, it references to a switch.

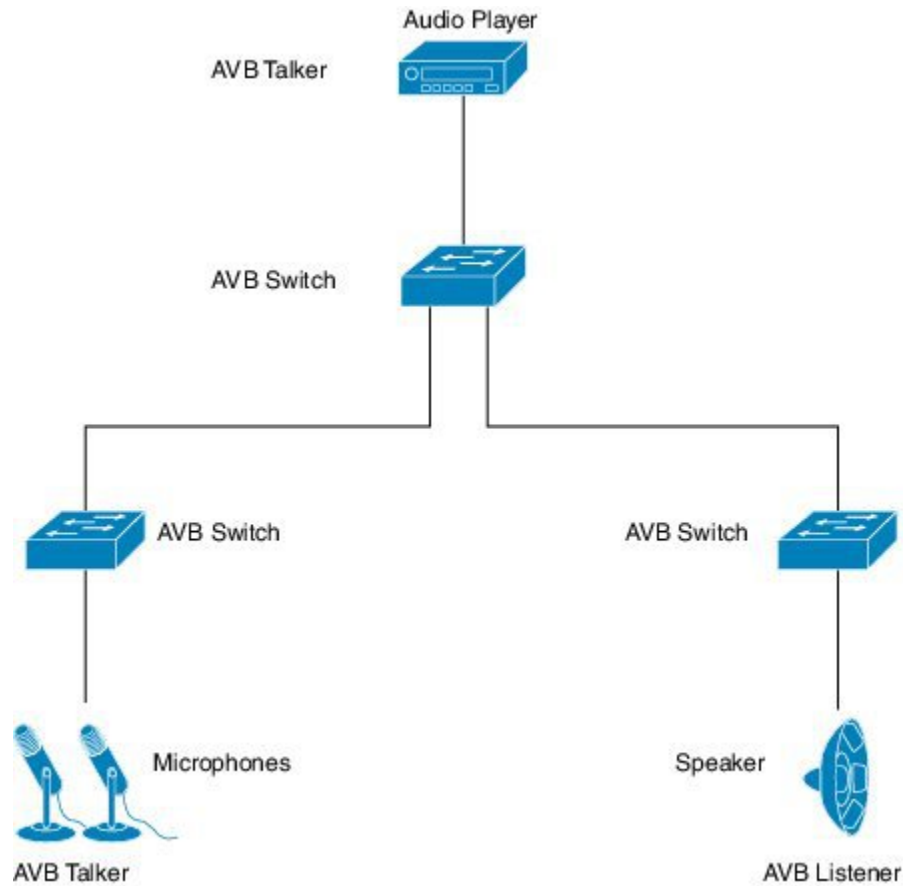
---

The IEEE 802.1BA specification requires that an AVB talker must be grandmaster capable. In a typical deployment a network node can also be the grandmaster, provided it can either source or derive timing from a grandmaster capable device and provide the timing to the AVB network using IEEE 802.1AS.

Figure 1 shows a simple illustration of AVB network with different components.



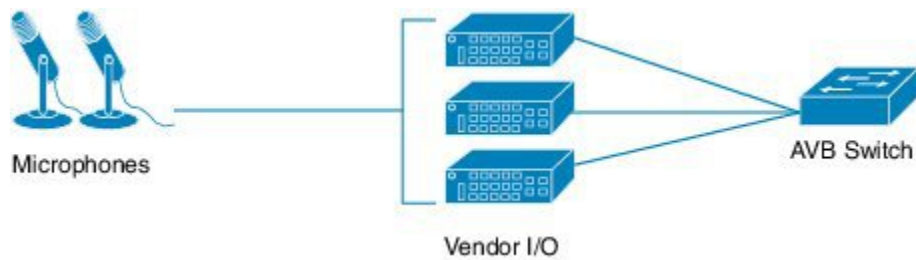
Figure 1: Figure 1: AVB Network



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In many instances, the Audio/Video end points (Microphone, Speaker, etc.) are analog devices. AVB end-point vendors introduce Digital Signal Processors (DSP) and I/O devices that provide extensive audio/video processing and aggregate the end-points into an AVB Ethernet interface, as shown in Figure 2.

Figure 2: Figure 2: Vendor audio I/O System



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## Supported SKUs for AVB

AVB is supported on the following Catalyst 3850 and Catalyst 3650 SKUs.

- WS-C3650-24PDM
- WS-C3650-48FQM

- WS-C3650-8X24UQ
- WS-C3650-12X48UQ
- WS-C3850-12X48U
- WS-C3850-12XS
- WS-C3850-16XS
- WS-C3850-24XS
- WS-C3850-24XU
- WS-C3850-32XS
- WS-C3850-48XS



---

**Note** In Cisco IOS XE Denali 16.3.1, AVB is supported only on the non-mGig interfaces on WS-3850-12X48U. Starting from Cisco IOS XE Denali 16.3.2, AVB is supported on the mGig interfaces on WS-3850-12X48U and WS-C3850-24XU.

---

## Information about Generalized Precision Time Protocol (gPTP)

Generalized Precision Time Protocol (gPTP) is an IEEE 802.1AS standard, which provides a mechanism to synchronize clocks of the bridges and end point devices in an AVB network. It defines the mechanism to elect the grandmaster clock (BMCA) among the time-aware bridges and talker and listener. The grandmaster is the root of the timing hierarchy that gets established in the time-aware network and distributes time to nodes below to enable synchronization.

Time synchronization also requires determining the link delay and switch delays in the network nodes. The gptp switch is a IEEE 1588 boundary clock, which also determines the link delay using the peer-to-peer delay mechanism. The delays computed are included in the correction field of the PTP messages and relayed to the end-points. The talker and listener use this gPTP time as a shared clock reference, which is used to relay and recover the media clock. gPTP currently defines only domain 0, which is what the switch supports.

The peer to peer delay mechanism runs on STP blocked ports as well. No other PTP messages are sent over blocked ports.

In a PTP domain, Best Master Clock (BMC) algorithm organizes Clocks and Ports into a hierarchical fashion, which includes clocks and port states:

### Clocks

- Grandmaster (GM/GMC)
- Boundary Clock (BC)

### Port States

- Master (M)
- Slave (S)
- Passive (P)

## Information about Multiple Stream Reservation Protocol (MSRP)

Multiple Stream Reservation Protocol (MSRP) provides a mechanism for end stations to reserve network resources that will guarantee the transmission and reception of data streams across a network with the requested QoS. It is one of the core protocols required on an AVB device (talker, listener and switches). It allows talkers to advertise streams across a network of AVB switches and listeners to register for receiving the streams.

MSRP is the key software protocol module for supporting AVB. It enables stream establishment and teardown. It interfaces with gPTP to update the latency information for the streams. It interfaces with the QoS module to setup the hardware resources that would guarantee requested bandwidth for the streams. It also provides the QoS shaping parameters required for the credit based shaper.



---

**Note** When AVB is enabled globally the default queuing values will be programmed to 1% bandwidth on the 10G interface. When stream reservation happens via MSRP, the ports will be moved accordingly from the boundary to the core port and the calculated bandwidth will be reserved for the outgoing interfaces for given streams. If a port is enabled with a capture feature like SPAN, RSPAN or Wireshark, there is no MSRP stream reservation. Queuing is programmed with default values of 1% for Class A & Class B of AVB traffic. Hence, all AVB traffic is rate limited to 1% of the bandwidth.

---

## Functions of MSRP

MSRP performs the following functions:

- Allows Talkers to advertise Streams and Listeners to discover and register for Streams.
- Establishes a path through an Ethernet between a Talker and one or more Listeners.
- Provides guaranteed bandwidth for AVB Streams.
- Guarantees an upper bound on latency.
- Discovers and reports the worst case end-to-end latency between the Talker and each of its Listeners.
- Reports failure reason and location when a path between the Talker and a Listener cannot satisfy bandwidth requirements.
- Supports multiple classes of traffic with different latency targets.
- Protects best effort traffic from starvation by limiting AVB traffic.
- MSRP Talker declarations are not forwarded along the STP blocked ports.
- MSRP listens to the STP TCN notification to generate MSRP declarations tear /modify / establish streams.

## Information about QoS HQoS

AVB networks guarantee bandwidth and minimum bounded latency for the time-sensitive audio and video streams. AVB defines Class A and Class B as the time-sensitive streams, based on the worst-case latency targets of the traffic from talker to listener.

The latency targets for the two streams are listed as below:

- SR-Class A: 2ms

- SR-Class B: 50ms

The sum of the worst-case latency contributions per hop should result in an overall end-to-end latency of 2 ms or less for SR-Class A and 50ms or less for SR-Class B. A typical AVB deployment of 7 hops from talker to listener meets these latency requirements.

The priority code points map the traffic to the specific stream. Frame forwarding behavior is based on this priority. A credit-based shaper is used to shape the transmission of these streams in accordance with the bandwidth that has been reserved on a given outbound queue so that the latency targets are met.

Starting with Cisco XE Denali 16.3.2, support for hierarchical QoS for AVB is enabled. AVB Hierarchical QoS policy is two level Parent-Child Policy. AVB Parent policy segregates audio, video traffic streams(SR-Class A , SR-Class B) and Network Control packets from standard best-effort ethernet traffic (Non-SR) and manage streams accordingly. Hierarchical QoS allows you to specify QoS behavior at multiple policy levels, which provides a high degree of granularity in traffic management. You can use hierarchical policies to:

- Allow a parent class to shape multiple queues in a child policy
- Apply specific policy map actions on the aggregate traffic
- Apply class-specific policy map actions

You can modify only ingress and egress HQoS child policy's class-map and its actions using **policy-map AVB-Output-Child-Policy** and **policy-map AVB-Input-Child-Policy** command.




---

**Note** You should not modify the PCP in child policy to map with PCP configured in Parent Policy, e.g. SR Class A cos 3 and SR Class B Cos 2.

---

### Hierarchical Policing

Hierarchical policing is supported on ingress and egress interfaces. Hierarchical QoS separates the SR and Non-SR class related rules into parent and child policies respectively. AVB SR classes are completely controlled by MSRP client and hence, parent policies containing SR class attributes are governed by MSRP. The end user has complete control over child policies which contain Non-SR class attributes and can modify only the child policies.

AVB HQoS child policies are user modifiable and NVGENed to preserve the configuration if user saves the configuration to the startup-config. So, AVB HQoS child policy configurations are retained even after reload.

## Information about Multiple VLAN Registration Protocol (MVRP)

Multiple VLAN Registration Protocol (MVRP) is an application based on MRP. MVRP provides a mechanism for dynamic maintenance of the contents of Dynamic VLAN Registration Entries for each vlan ids, and for propagating the information they contain to other Bridges. This information allows MVRP-aware devices to dynamically establish and update their knowledge of the set of vlan ids associated with VLANs that currently have active members, and through which Ports those members can be reached.

MVRP, from an AVB perspective, is mandatory on the talkers and the listeners. Independent of AVB, MVRP is an IEEE 802.1Q requirement on the VLAN-aware switches. However, manual configuration of VLANs on the switches is sufficient for AVB.



**Note** VTP should be in the disabled mode or transparent mode for MVRP to work.

# Configuring the AVB Network

## Configuring AVB

This section describes the various configurations available for AVB.

### Enabling AVB on the switch

Perform the following task to enable AVB on the switch.



**Note** Both, the **avb** and **avb strict** commands must be configured to enable AVB.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>avb</b> <b>Example:</b> Device(config)# <b>avb</b>	Enables AVB on the switch.
<b>Step 4</b>	<b>avb strict</b> <b>Example:</b> Device(config)# <b>avb strict</b>	Enables AVB on the switch. This command is used in combination with the <b>avb</b> command to enable AVB. <b>Note</b> This command will be deprecated in the future releases.

	Command or Action	Purpose
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

**What to do next**

To disable AVB on the switch, use the "no" form of the command.

**Configuring AVB on the devices**

You can configure the interfaces along the connectivity path for AVB devices as dot1q trunk ports by using the below commands.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface tel1/1/1</b>	Defines the interface to be configured as a trunk, and enters interface configuration mode.
<b>Step 4</b>	<b>switchport mode trunk</b> <b>Example:</b> Device(config-if)# <b>switchport mode trunk</b>	Configures the port as a trunk port.
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config-if)# <b>exit</b>	Returns to global configuration mode.

	Command or Action	Purpose
<b>Step 6</b>	<b>vlan 2</b> <b>Example:</b> Device(config) # <b>vlan 2</b>	Configures VLAN 2 on the switch. <b>Note</b> VLAN 2 is the default AVB VLAN. If you need to configure another VLAN as the default AVB VLAN, use the command in Step 7.
<b>Step 7</b>	<b>avb vlan <i>vlan-id</i></b> <b>Example:</b> Device(config) # <b>avb vlan 10</b>	(Optional) Sets the specified VLAN as the default AVB VLAN on the switch. Use this command when you need to set the default AVB VLAN other than VLAN 2. The range for <i>vlan-id</i> varies from 2 to 4094.
<b>Step 8</b>	<b>avb</b> <b>Example:</b> Device(config-vlan) # <b>avb</b>	Configures AVB on the specified interface.
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device(config) # <b>end</b>	Returns to privileged EXEC mode.

**What to do next**

To disable AVB on the switch, use the "no" form of the command.

## Configuring gPTP

This section describes the various configurations available for gPTP.

### Enabling gPTP on a port

When AVB is enabled on the switch, gPTP for AVB also gets enabled.



**Note** When gPTP is enabled, Flowcontrol is disabled on all ports.

You can also enable gPTP globally using the command given below:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
	Device> <b>enable</b>	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ptp profile dot1as</b> <b>Example:</b> Device(config)# <b>ptp profile dot1as</b>	Enables gPTP on the port.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

### Enabling gPTP on an interface

You can also enable gPTP on an interface using the command given below:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 3</b>	<b>interface interface-id</b> <b>Example:</b> Device(config)# <b>interface tel1/1/1</b>	Defines the interface to be configured as a trunk, and enters interface configuration mode.
<b>Step 4</b>	<b>ptp enable</b> <b>Example:</b> Device(config-if)# <b>ptp enable</b>	Enables gPTP on the specified interface.  To disable gPTP on the interface, use the no form of this command as shown below:  Device(config-if)# <b>no ptp enable</b>



	Command or Action	Purpose
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-if) # <b>end</b>	Returns to privileged EXEC mode.

## Configuring the values of PTP clocks

You can configure the values of ptp clock priority1 and priority2 using the commands below:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ptp priority1</b> <b>Example:</b> Device(config) # <b>ptp priority1</b>	Configure the values of ptp clock priority1. 0-255 - This is the range for the value of the ptp clock priority. Select a value within this range. <b>Note</b> If the value of priority1 is configured to 255, the clock cannot become as Grandmaster.
<b>Step 4</b>	<b>ptp priority2</b> <b>Example:</b> Device(config) # <b>ptp priority2</b>	Configure the values of ptp clock priority2. 0-255 - This is the range for the value of the ptp clock priority. Select a value within this range.
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config) # <b>exit</b>	Returns to global configuration mode.

## Configuring HQoS

This section describes the various configurations available for HQoS.

## Enabling HQoS

When AVB is enabled on the switch, HQoS for AVB also gets enabled.

## Migrating from Flat Policy Formats to Hierarchical Policy Formats - Guidelines and Restrictions

Follow the below guidelines when migrating from flat policy formats to hierarchical policy formats for AVB:

- If you upgrade from Cisco IOS XE Denali 16.3.1 to Cisco IOS XE Denali 16.3.2, QoS policies that are in startup configuration of the device will fail with errors. Follow the steps below to properly install HQoS policies on your device:

1. Use the **no avb** command to disable AVB globally.




---

**Note** When you disable AVB, all the policy-maps and class-maps are automatically removed from the configuration. But, the access-lists are not removed automatically. You must remove the access-lists manually. Ensure that all the QoS policy constructs are removed before upgrading to Cisco IOS XE Denali 16.3.2.

---

2. Enable AVB using the **avb** command. When AVB is enabled, HQoS for AVB also gets enabled.
- We do not recommend migrating from a hierarchical policy format supported release to a flat policy format supported release.
  - You can only modify child policies. Parent policies are completely governed by MSRP.
  - **show running config** command displays only the child policies.
  - Starting from Cisco IOS XE Denali 16.3.2, **show running config interface** command will not display any details of the policy attached. You should use **show policy-map interface** command for displaying all the details of the policy attached.

## Hierarchical QoS Policy Formats

This following example shows hierarchical remarking policy at the ingress interface:

```

policy-map AVB-Input-Child-Policy
  class VOIP-DATA-CLASS
    set dscp EF
  class MULTIMEDIA-CONF-CLASS
    set dscp AF41
  class BULK-DATA-CLASS
    set dscp AF11
  class TRANSACTIONAL-DATA-CLASS
    set dscp AF21
  class SCAVENGER-DATA-CLASS
    set dscp CS1
  class SIGNALING-CLASS
    set dscp CS3
  class class-default
    set dscp default

policy-map AVB-Input-Policy-Remark-AB
  class AVB-SR-A-CLASS
    set cos 0 (set 0 for boundary & SR class A PCP value for core port)

```

```

class AVB-SR-B-CLASS
  set cos 0 (set 0 for boundary & SR class B PCP value for core port)
class class-default
  service-policy AVB-Input-Child-Policy

policy-map AVB-Input-Policy-Remark-A
class AVB-SR-A-CLASS
  set cos 0 (set 0 for boundary & SR class A PCP value for core port)
class class-default
  service-policy AVB-Input-Child-Policy

policy-map AVB-Input-Policy-Remark-B
class AVB-SR-B-CLASS
  set cos 0 (set 0 for boundary & SR class B PCP value for core port)
class class-default
  service-policy AVB-Input-Child-Policy

policy-map AVB-Input-Policy-Remark-None
class class-default
  service-policy AVB-Input-Child-Policy

```

This following example shows hierarchical queuing policy at the egress interface:

```

policy-map AVB-Output-Child-Policy
class VOIP-PRIORITY-QUEUE
  bandwidth remaining percent 30
  queue-buffers ratio 10
class MULTIMEDIA-CONFERENCING-STREAMING-QUEUE
  bandwidth remaining percent 15
  queue-limit dscp AF41 percent 80
  queue-limit dscp AF31 percent 80
  queue-limit dscp AF42 percent 90
  queue-limit dscp AF32 percent 90
  queue-buffers ratio 10
class TRANSACTIONAL-DATA-QUEUE
  bandwidth remaining percent 15
  queue-limit dscp AF21 percent 80
  queue-limit dscp AF22 percent 90
  queue-buffers ratio 10
class BULK-SCAVENGER-DATA-QUEUE
  bandwidth remaining percent 15
  queue-limit dscp AF11 percent 80
  queue-limit dscp AF12 percent 90
  queue-limit dscp CS1 percent 80
  queue-buffers ratio 15
class class-default
  bandwidth remaining percent 25
  queue-buffers ratio 25

policy-map AVB-Output-Policy
class AVB-SR-A-CLASS
  priority level 1 (Shaper value based on stream registration)
class AVB-SR-B-CLASS
  priority level 2 (Shaper value based on stream registration)
class CONTROL-MGMT-QUEUE
  priority level 3 percent 15
class class-default
  bandwidth remaining percent 100
  queue-buffers ratio 80
  service-policy AVB-Output-Child-Policy

```

## Configuring MVRP

This section describes the various configurations available for MVRP.

### Enabling MVRP

You can enable MVRP on the switches in the topology to enable Vlan propagation using the below command.



#### Note

You must change VTP mode to **transparent** or **off**, before enabling dynamic vlan creation via MVRP.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>mvrp global</b> <b>Example:</b> Device(config)# <b>mvrp global</b>	Enters the MVRP Global configuration mode.
<b>Step 4</b>	<b>vtp mode {transparent   off}</b> <b>Example:</b> Device(config)# <b>vtp mode transparent</b> <b>Example:</b> Device(config)# <b>vtp mode off</b>	Sets the VTP to <b>transparent</b> or <b>off</b> mode.
<b>Step 5</b>	<b>mvrp vlan create</b> <b>Example:</b> Device(config)# <b>mvrp vlan create</b>	Enables MVRP on the switches.

## Configuring MVRP on the switch interface

You can configure MVRP on the switch interfaces using the below commands

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface</b> <b>te1/1/1</b>	Defines the interface to be configured as a trunk, and enters interface configuration mode.
<b>Step 4</b>	<b>mvrp registration {<i>fixed</i>   <i>forbidden</i>   <i>normal</i>}</b> <b>Example:</b> Device(config-if)# <b>mvrp registration</b> <b>fixed</b>	Registers MVRP with the MAD instance. <ul style="list-style-type: none"> <li>• fixed - Fixed registration</li> <li>• forbidden - Forbidden registration</li> <li>• normal - Normal registration</li> </ul>
<b>Step 5</b>	<b>mvrp timer {<i>join</i>   <i>leave</i>   <i>leave-all</i>   <i>periodic</i>}</b> <b>Example:</b> Device(config-if)# <b>mvrp timer</b> <b>join</b>	Configures the MVRP timer. <ul style="list-style-type: none"> <li>• join - Timer controls the interval between transmit opportunities that are applied to the ASM</li> <li>• leave - The timer controls the RSM waits in the LV state before transiting to the MT state</li> <li>• leave-all - The timer control the frequency with which the LeaveAll SM generates LeaveAll PDUs</li> <li>• periodic - Periodic timer</li> </ul>
<b>Step 6</b>	<b>exit</b> <b>Example:</b>	Returns to global configuration mode.

	Command or Action	Purpose
	Device (config-if) # <b>exit</b>	

## Monitoring the AVB Network

### Monitoring AVB

To display the AVB details, use the commands in the following table:

Command	Purpose
<b>show avb domain</b>	Displays the AVB domain.
<b>show avb streams</b>	Displays the AVB stream information.

### Monitoring gPTP

To display the gPTP protocol details, use the commands in the following table:

Command	Purpose
<b>show ptp brief</b>	Displays a brief status of ptp on the interfaces.
<b>show ptp clock</b>	Displays ptp clock information.
<b>show ptp parent</b>	Displays the parent clock information.
<b>show ptp port</b>	Displays the ptp port information.
<b>show platform software fed switch active ptp if-id {interface-id}</b>	Displays details info about ptp status on the port.

### Monitoring MSRP

To display the MSRP details, use the commands in the following table:

Command	Purpose
<b>show msrp streams</b>	Displays MSRP stream information.
<b>show msrp streams detailed</b>	Displays detailed MSRP stream information.
<b>show msrp streams brief</b>	Displays MSRP stream information in brief.
<b>show msrp port bandwidth</b>	Displays MSRP port bandwidth information.

## Monitoring HQoS

To display the HQoS details, use the commands in the following table:

Command	Purpose
<b>show run</b>	Displays all the child policy map details.
<b>show policy-map</b>	Displays the details of the policy map configuration.
<b>show platform hardware fed switch active qos queue stats interface <i>interface-id</i></b>	Displays the QoS statistics for different queue mappings in AVB.
<b>show platform hardware fed switch active qos queue config interface <i>interface-id</i></b>	Displays the QoS queue configurations.
<b>show policy-map interface <i>interface-id</i> [input   output]</b>	Displays the AVB QoS statistics. Packet counters for ingress and bytes counters for egress are accounted for QoS Statistics.

## Monitoring MVRP

To display the MVRP details, use the commands in the following table:

Command	Purpose
<b>show mvrp summary</b>	Displays MVRP summary information.
<b>show mvrp interface</b>	Displays interface MVRP information.

## Examples of AVB Configurations and Monitoring

### Examples for AVB

This example shows how you can view the AVB domain.

```
Device#show avb domain

AVB Class-A
  Priority Code Point      : 3
  VLAN                    : 2
  Core ports              : 1
  Boundary ports         : 67

AVB Class-B
  Priority Code Point      : 2
  VLAN                    : 2
  Core ports              : 1
  Boundary ports         : 67
```

Interface	State	Delay	PCP	VID	Information
Tel/0/1	down	N/A			Oper state not up
Tel/0/2	down	N/A			Oper state not up
Tel/0/3	down	N/A			Oper state not up
Tel/0/4	down	N/A			Oper state not up
Tel/0/5	up	N/A			Port is not asCapable
Tel/0/6	down	N/A			Oper state not up
Tel/0/7	down	N/A			Oper state not up
Tel/0/8	down	N/A			Oper state not up
Tel/0/9	down	N/A			Oper state not up
Tel/0/10	down	N/A			Oper state not up
Tel/0/11	down	N/A			Oper state not up
Tel/0/12	down	N/A			Oper state not up
Tel/0/13	down	N/A			Oper state not up
Tel/0/14	down	N/A			Oper state not up
Tel/0/15	down	N/A			Oper state not up
Tel/0/16	down	N/A			Oper state not up
Tel/0/17	down	N/A			Oper state not up
Tel/0/18	down	N/A			Oper state not up
Tel/0/19	up	N/A			Port is not asCapable
Tel/0/20	down	N/A			Oper state not up
Tel/0/21	down	N/A			Oper state not up
Tel/0/22	down	N/A			Oper state not up
Tel/0/23	up	N/A			Port is not asCapable
Tel/0/24	down	N/A			Oper state not up
Tel/0/25	down	N/A			Oper state not up
Tel/0/26	down	N/A			Oper state not up
Tel/0/27	down	N/A			Oper state not up
Tel/0/28	down	N/A			Oper state not up
Tel/0/29	up	N/A			Port is not asCapable
Tel/0/30	down	N/A			Oper state not up
Tel/0/31	down	N/A			Oper state not up
Tel/0/32	down	N/A			Oper state not up
Tel/0/33	down	N/A			Oper state not up
Tel/0/34	down	N/A			Oper state not up
Tel/0/35	up	N/A			Port is not asCapable
Tel/0/36	down	N/A			Oper state not up
Tel/0/37	down	N/A			Oper state not up
Tel/0/38	down	N/A			Oper state not up
Tel/0/39	up	507ns			
Class-	A	core	3	2	
Class-	B	core	2	2	
Tel/0/40	down	N/A			Oper state not up
Tel/0/41	down	N/A			Oper state not up
Tel/0/42	down	N/A			Oper state not up
Tel/0/43	down	N/A			Oper state not up



```

Te1/0/44      down      N/A      Oper state not up
Te1/0/45      down      N/A      Oper state not up
Te1/0/46      down      N/A      Oper state not up
Te1/0/47      down      N/A      Oper state not up
Te1/0/48      down      N/A      Oper state not up
Te1/1/1       down      N/A      Oper state not up
Te1/1/2       down      N/A      Oper state not up
Te1/1/3       down      N/A      Oper state not up
Te1/1/4       down      N/A      Oper state not up
Te1/1/5       down      N/A      Oper state not up
Te1/1/6       down      N/A      Oper state not up
Te1/1/7       down      N/A      Oper state not up
Te1/1/8       down      N/A      Oper state not up
Te1/1/9       down      N/A      Oper state not up
Te1/1/10      down      N/A      Oper state not up
Te1/1/11      down      N/A      Oper state not up
Te1/1/12      down      N/A      Oper state not up
Te1/1/13      down      N/A      Oper state not up
Te1/1/14      down      N/A      Oper state not up
Te1/1/15      down      N/A      Oper state not up
Te1/1/16      down      N/A      Oper state not up
Fo1/1/1       down      N/A      Oper state not up
Fo1/1/2       down      N/A      Oper state not up
Fo1/1/3       down      N/A      Oper state not up
Fo1/1/4       down      N/A      Oper state not up

```

-----

This example shows how you can view the AVB stream information.

Device#**show avb streams**

```

Stream ID:      0011.0100.0001:1      Incoming Interface:  Te1/1/1
  Destination   : 91E0.F000.FE00
  Class        : A
  Rank         : 1
  Bandwidth    : 6400 Kbit/s

```

Outgoing Interfaces:

```

-----
Interface      State      Time of Last Update      Information
-----
Te1/1/1        Ready      Tue Apr 26 01:25:40.634

```

```

Stream ID:      0011.0100.0002:2      Incoming Interface:  Te1/1/1
  Destination   : 91E0.F000.FE01
  Class        : A

```

```
Rank          : 1
Bandwidth     : 6400 Kbit/s
```

Outgoing Interfaces:

```
-----
```

Interface	State	Time of Last Update	Information
Tel1/1/1	Ready	Tue Apr 26 01:25:40.634	

```
-----
```

## Examples for gPTP

This command can be used to see a brief status of ptp on the interfaces.

```
Device#show ptp brief
```

Interface	Domain	PTP State
FortyGigabitEthernet1/1/1	0	FAULTY
FortyGigabitEthernet1/1/2	0	SLAVE
GigabitEthernet1/1/1	0	FAULTY
GigabitEthernet1/1/2	0	FAULTY
GigabitEthernet1/1/3	0	FAULTY
GigabitEthernet1/1/4	0	FAULTY
TenGigabitEthernet1/0/1	0	FAULTY
TenGigabitEthernet1/0/2	0	FAULTY
TenGigabitEthernet1/0/3	0	MASTER
TenGigabitEthernet1/0/4	0	FAULTY
TenGigabitEthernet1/0/5	0	FAULTY
TenGigabitEthernet1/0/6	0	FAULTY
TenGigabitEthernet1/0/7	0	MASTER
TenGigabitEthernet1/0/8	0	FAULTY
TenGigabitEthernet1/0/9	0	FAULTY
TenGigabitEthernet1/0/10	0	FAULTY
TenGigabitEthernet1/0/11	0	MASTER
TenGigabitEthernet1/0/12	0	FAULTY
TenGigabitEthernet1/0/13	0	FAULTY
TenGigabitEthernet1/0/14	0	FAULTY
TenGigabitEthernet1/0/15	0	FAULTY
TenGigabitEthernet1/0/16	0	FAULTY
TenGigabitEthernet1/0/17	0	FAULTY
TenGigabitEthernet1/0/18	0	FAULTY
TenGigabitEthernet1/0/19	0	MASTER
TenGigabitEthernet1/0/20	0	FAULTY
TenGigabitEthernet1/0/21	0	FAULTY
TenGigabitEthernet1/0/22	0	FAULTY
TenGigabitEthernet1/0/23	0	FAULTY
TenGigabitEthernet1/0/24	0	FAULTY
TenGigabitEthernet1/1/1	0	FAULTY

```
TenGigabitEthernet1/1/2      0      FAULTY
TenGigabitEthernet1/1/3      0      FAULTY
TenGigabitEthernet1/1/4      0      FAULTY
TenGigabitEthernet1/1/5      0      FAULTY
TenGigabitEthernet1/1/6      0      FAULTY
TenGigabitEthernet1/1/7      0      FAULTY
TenGigabitEthernet1/1/8      0      FAULTY
```

---

This command can be used to view ptp clock information.

```
Device#show ptp clock

PTP CLOCK INFO
  PTP Device Type: Boundary clock
  PTP Device Profile: IEEE 802/1AS Profile
  Clock Identity: 0x4:6C:9D:FF:FE:4F:95:0
  Clock Domain: 0
  Number of PTP ports: 38
  PTP Packet priority: 4
  Priority1: 128
  Priority2: 128
  Clock Quality:
    Class: 248
    Accuracy: Unknown
    Offset (log variance): 16640
  Offset From Master(ns): 0
  Mean Path Delay(ns): 0
  Steps Removed: 3
  Local clock time: 00:12:13 UTC Jan 1 1970
```

---

This command can be used to view the parent clock information.

```
Device#show ptp parent

PTP PARENT PROPERTIES
  Parent Clock:
  Parent Clock Identity: 0xB0:7D:47:FF:FE:9E:B6:80
  Parent Port Number: 3
  Observed Parent Offset (log variance): 16640
  Observed Parent Clock Phase Change Rate: N/A

  Grandmaster Clock:
  Grandmaster Clock Identity: 0x4:6C:9D:FF:FE:67:3A:80
  Grandmaster Clock Quality:
    Class: 248
    Accuracy: Unknown
    Offset (log variance): 16640
    Priority1: 0
    Priority2: 128
```

---

This command can be used to view the ptp port information.

Device#**show ptp port**

```
PTP PORT DATASET: FortyGigabitEthernet1/1/1
  Port identity: clock identity: 0x4:6C:9D:FF:FE:4E:3A:80
  Port identity: port number: 1
  PTP version: 2
  Port state: FAULTY
  Delay request interval(log mean): 5
  Announce receipt time out: 3
  Peer mean path delay(ns): 0
  Announce interval(log mean): 1
  Sync interval(log mean): 0
  Delay Mechanism: End to End
  Peer delay request interval(log mean): 0
  Sync fault limit: 500000000

PTP PORT DATASET: FortyGigabitEthernet1/1/2
  Port identity: clock identity: 0x4:6C:9D:FF:FE:4E:3A:80
  Port identity: port number: 2
  PTP version: 2
  Port state: FAULTY
  Delay request interval(log mean): 5
  Announce receipt time out: 3
  Peer mean path delay(ns): 0
  Announce interval(log mean): 1
--More--
```

---

This command can be used to view the port information for a particular interface.

Device#**show ptp port gi1/0/26**

```
PTP PORT DATASET: GigabitEthernet1/0/26
  Port identity: clock identity: 0x4:6C:9D:FF:FE:4E:3A:80
  Port identity: port number: 28
  PTP version: 2
  Port state: MASTER
  Delay request interval(log mean): 5
  Announce receipt time out: 3
  Peer mean path delay(ns): 0
  Announce interval(log mean): 1
  Sync interval(log mean): 0
  Delay Mechanism: Peer to Peer
  Peer delay request interval(log mean): 0
  Sync fault limit: 500000000
```

---

This command can be used to view the

```

Device#show platform software fed switch active ptp if-id 0x20

Displaying port data for if_id 20
=====

Port Mac Address 04:6C:9D:4E:3A:9A
Port Clock Identity 04:6C:9D:FF:FE:4E:3A:80
Port number 28
PTP Version 2
domain_value 0
dot1as_capable: FALSE
sync_recpt_timeout_time_interval 375000000 nanoseconds
sync_interval 125000000 nanoseconds
neighbor_rate_ratio 0.000000
neighbor_prop_delay 0 nanoseconds
compute_neighbor_rate_ratio: TRUE
compute_neighbor_prop_delay: TRUE
port_enabled: TRUE
ptt_port_enabled: TRUE
current_log_pdelay_req_interval 0
pdelay_req_interval 0 nanoseconds
allowed_lost_responses 3
neighbor_prop_delay_threshold 2000 nanoseconds
is_measuring_delay : FALSE
Port state: : MASTER
sync_seq_num 22023
delay_req_seq_num 23857
num sync messages transmitted 0
num sync messages received 0
num followup messages transmitted 0
num followup messages received 0
num pdelay requests transmitted 285695
num pdelay requests received 0
num pdelay responses transmitted 0
num pdelay responses received 0
num pdelay followup responses transmitted 0
num pdelay followup responses received 0

```

## Examples for MSRP

This example shows how you can view the MSRP stream information.

```
Device#show msrp streams
```

```

-----
Stream ID Talker Listener
Advertise Fail Ready ReadyFail AskFail
R | D R | D R | D R | D R | D
-----

```

```
yy:yy:yy:yy:yy:yy:0001 1 | 2 0 | 0 1 | 0 0 | 1 1 | 0
zz:zz:zz:zz:zz:zz:0002 1 | 0 0 | 1 1 | 0 0 | 0 0 | 1
```

-----

This example shows how you can view the detailed MSRP stream information.

```
Device#show msrp streams detail
```

```
Stream ID:          0011.0100.0001:1
  Stream Age: 01:57:46 (since Mon Apr 25 23:41:11.413)
  Create Time: Mon Apr 25 23:41:11.413
  Destination Address: 91E0.F000.FE00
  VLAN Identifier: 1
  Data Frame Priority: 3 (Class A)
  MaxFrameSize: 100
  MaxIntervalFrames: 1 frames/125us
  Stream Bandwidth: 6400 Kbit/s
  Rank: 1
  Received Accumulated Latency: 20
  Stream Attributes Table:
```

```
-----
```

Interface	Attr State	Direction	Type
Gil/0/1	Register	Talker	Advertise
Attribute Age: 01:57:46 (since Mon Apr 25 23:41:11.413)			
MRP Applicant: Very Anxious Observer, send None			
MRP Registrar: In			
Accumulated Latency: 20			
----			
Tel/1/1	Declare	Talker	Advertise
Attribute Age: 00:19:52 (since Tue Apr 26 01:19:05.525)			
MRP Applicant: Quiet Active, send None			
MRP Registrar: In			
Accumulated Latency: 20			
----			
Tel/1/1	Register	Listener	Ready
Attribute Age: 00:13:17 (since Tue Apr 26 01:25:40.635)			
MRP Applicant: Very Anxious Observer, send None			
MRP Registrar: In			
----			
Gil/0/1	Declare	Listener	Ready
Attribute Age: 00:13:17 (since Tue Apr 26 01:25:40.649)			
MRP Applicant: Quiet Active, send None			
MRP Registrar: In			

```
-----
```

This example shows how you can view the MSRP stream information in brief.

Device#show msrp streams brief

Legend: R = Registered, D = Declared.

Stream ID Fail	Destination Address	Bandwidth (Kbit/s)	Talkers R   D	Listeners R   D
0011.0100.0001:1 No	91E0.F000.FE00	6400	1   1	1   1
0011.0100.0002:2 No	91E0.F000.FE01	6400	1   1	1   1
0011.0100.0003:3 No	91E0.F000.FE02	6400	1   1	1   1
0011.0100.0004:4 No	91E0.F000.FE03	6400	1   1	1   1
0011.0100.0005:5 No	91E0.F000.FE04	6400	1   1	1   1
0011.0100.0006:6 No	91E0.F000.FE05	6400	1   1	1   1
0011.0100.0007:7 No	91E0.F000.FE06	6400	1   1	1   1
0011.0100.0008:8 No	91E0.F000.FE07	6400	1   1	1   1
0011.0100.0009:9 No	91E0.F000.FE08	6400	1   1	1   1
0011.0100.000A:10 No	91E0.F000.FE09	6400	1   1	1   1

This example shows how you can view the MSRP port bandwidth information.

Device#show msrp port bandwidth

Ethernet Interface	Capacity (Kbit/s)	Assigned A   B	Available A   B	Reserved A   B
Tel1/0/1	10000000	75   0	75   75	0   0
Tel1/0/2	10000000	75   0	75   75	0   0
Tel1/0/3	1000000	75   0	75   75	0   0
Tel1/0/4	10000000	75   0	75   75	0   0
Tel1/0/5	10000000	75   0	75   75	0   0
Tel1/0/6	10000000	75   0	75   75	0   0
Tel1/0/8	10000000	75   0	75   75	0   0
Tel1/0/9	10000000	75   0	75   75	0   0
Tel1/0/10	10000000	75   0	75   75	0   0
Tel1/0/11	10000000	75   0	75   75	0   0
Tel1/0/12	10000000	75   0	75   75	0   0
Tel1/0/13	1000000	75   0	75   75	0   0
Tel1/0/14	10000000	75   0	75   75	0   0

Tel/0/15	10000000	75   0	75   75	0   0
Tel/0/16	10000000	75   0	75   75	0   0
Tel/0/17	10000000	75   0	75   75	0   0
Tel/0/18	10000000	75   0	75   75	0   0
Tel/0/19	10000000	75   0	75   75	0   0
Tel/0/20	10000000	75   0	75   75	0   0
Tel/0/21	10000000	75   0	75   75	0   0
Tel/0/22	10000000	75   0	75   75	0   0
Tel/0/23	10000000	75   0	75   75	0   0
Tel/0/24	10000000	75   0	75   75	0   0
Gil/1/1	1000000	75   0	75   75	0   0
Gil/1/2	1000000	75   0	75   75	0   0
Gil/1/3	1000000	75   0	75   75	0   0
Gil/1/4	1000000	75   0	75   75	0   0
Tel/1/1	10000000	75   0	75   75	0   0
Tel/1/2	10000000	75   0	75   75	0   0
Tel/1/3	10000000	75   0	75   75	0   0
Tel/1/4	10000000	75   0	75   75	0   0
Tel/1/5	10000000	75   0	75   75	0   0
Tel/1/6	10000000	75   0	75   75	0   0
Tel/1/7	10000000	75   0	75   75	0   0
Tel/1/8	10000000	75   0	75   75	0   0
Fo1/1/1	40000000	75   0	75   75	0   0
Fo1/1/2	40000000	75   0	75   75	0   0

## Examples for HQoS

This example shows how you can view all the policy-map configuration details when AVB is enabled.

Device#**show policy-map**

```

Policy Map AVB-Input-Policy-Remark-B
  Class AVB-SR-CLASS-A
    set cos 3
  Class AVB-SR-CLASS-B
    set cos 0
  Class class-default
    service-policy AVB-Input-Child-Policy

Policy Map AVB-Input-Policy-Remark-A
  Class AVB-SR-CLASS-A
    set cos 0
  Class AVB-SR-CLASS-B
    set cos 2
  Class class-default
    service-policy AVB-Input-Child-Policy

Policy Map AVB-Output-Policy-Default
  Class AVB-SR-CLASS-A
    priority level 1 1 (%)
  Class AVB-SR-CLASS-B

```



```
    priority level 2 1 (%)
Class AVB-CONTROL-MGMT-QUEUE
    priority level 3 15 (%)
Class class-default
    bandwidth remaining 100 (%)
    queue-buffers ratio 70
    service-policy AVB-Output-Child-Policy

Policy Map AVB-Input-Policy-Remark-AB
Class AVB-SR-CLASS-A
    set cos 0
Class AVB-SR-CLASS-B
    set cos 0
Class class-default
    service-policy AVB-Input-Child-Policy

Policy Map AVB-Input-Policy-Remark-None
Class AVB-SR-CLASS-A
    set cos 3
Class AVB-SR-CLASS-B
    set cos 2
Class class-default
    service-policy AVB-Input-Child-Policy

Policy Map AVB-Input-Child-Policy
Class AVB-VOIP-DATA-CLASS
    set dscp ef
Class AVB-MULTIMEDIA-CONF-CLASS
    set dscp af41
Class AVB-BULK-DATA-CLASS
    set dscp af11
Class AVB-TRANSACTIONAL-DATA-CLASS
    set dscp af21
Class AVB-SCAVENGER-DATA-CLASS
    set dscp cs1
Class AVB-SIGNALING-CLASS
    set dscp cs3
Class class-default
    set dscp default

Policy Map AVB-Output-Child-Policy
Class AVB-VOIP-PRIORITY-QUEUE
    bandwidth remaining 30 (%)
    queue-buffers ratio 30
Class AVB-MULTIMEDIA-CONF-STREAMING-QUEUE
    bandwidth remaining 15 (%)
    queue-limit dscp af41 percent 80
    queue-limit dscp af31 percent 80
    queue-limit dscp af42 percent 90
    queue-limit dscp af32 percent 90
    queue-buffers ratio 15
```

```

Class AVB-TRANSACTIONAL-DATA-QUEUE
  bandwidth remaining 15 (%)
  queue-limit dscp af21 percent 80
  queue-limit dscp af22 percent 90
  queue-buffers ratio 15
Class AVB-BULK-SCAVENGER-DATA-QUEUE
  bandwidth remaining 15 (%)
  queue-limit dscp af11 percent 80
  queue-limit dscp af12 percent 90
  queue-limit dscp cs1 percent 80
  queue-buffers ratio 15
Class class-default
  bandwidth remaining 25 (%)
  queue-buffers ratio 25

```

---

This example shows how you can view all the policy-map configuration details when AVB is disabled.

Device#**show policy-map**

Building configuration...

```

Current configuration : 2079 bytes
!
policy-map AVB-Input-Child-Policy
class AVB-VOIP-DATA-CLASS
  set dscp ef
class AVB-MULTIMEDIA-CONF-CLASS
  set dscp af41
class AVB-BULK-DATA-CLASS
  set dscp af11
class AVB-TRANSACTIONAL-DATA-CLASS
  set dscp af21
class AVB-SCAVENGER-DATA-CLASS
  set dscp cs1
class AVB-SIGNALING-CLASS
  set dscp cs3
class class-default
  set dscp default
policy-map AVB-Output-Child-Policy
class AVB-VOIP-PRIORITY-QUEUE
  bandwidth remaining percent 30
  queue-buffers ratio 30
class AVB-MULTIMEDIA-CONF-STREAMING-QUEUE
  bandwidth remaining percent 15
  queue-limit dscp af41 percent 80
  queue-limit dscp af31 percent 80
  queue-limit dscp af42 percent 90
  queue-limit dscp af32 percent 90

```

```

    queue-buffers ratio 15
class AVB-TRANSACTIONAL-DATA-QUEUE
    bandwidth remaining percent 15
    queue-limit dscp af21 percent 80
    queue-limit dscp af22 percent 90
    queue-buffers ratio 15
class AVB-BULK-SCAVENGER-DATA-QUEUE
    bandwidth remaining percent 15
    queue-limit dscp af11 percent 80
    queue-limit dscp af12 percent 90
    queue-limit dscp cs1 percent 80
    queue-buffers ratio 15
class class-default
    bandwidth remaining percent 25
    queue-buffers ratio 25
!
end

```

---

This example shows how you can view all the class-map configuration details when AVB is enabled.

Device#**show class-map**

```

Class Map match-any AVB-VOIP-DATA-CLASS (id 31)
    Match dscp ef (46)
    Match cos 5

Class Map match-any AVB-BULK-DATA-CLASS (id 33)
    Match access-group name AVB-BULK-DATA-CLASS-ACL

Class Map match-any AVB-VOIP-PRIORITY-QUEUE (id 37)
    Match dscp cs4 (32) cs5 (40) ef (46)
    Match precedence 4 5
    Match cos 5

Class Map match-any AVB-MULTIMEDIA-CONF-CLASS (id 32)
    Match access-group name AVB-MULTIMEDIA-CONF-CLASS-ACL

Class Map match-any AVB-SIGNALING-CLASS (id 36)
    Match access-group name AVB-SIGNALING-CLASS-ACL

Class Map match-any AVB-MULTIMEDIA-CONF-STREAMING-QUEUE (id 38)
    Match dscp af41 (34) af42 (36) af43 (38)
    Match dscp af31 (26) af32 (28) af33 (30)
    Match cos 4

Class Map match-any AVB-BULK-SCAVENGER-DATA-QUEUE (id 40)
    Match dscp cs1 (8) af11 (10) af12 (12) af13 (14)
    Match precedence 1

```

```

Match cos 1

Class Map match-any AVB-TRANSACTIONAL-DATA-CLASS (id 34)
  Match access-group name AVB-TRANSACTIONAL-DATA-CLASS-ACL

Class Map match-any AVB-TRANSACTIONAL-DATA-QUEUE (id 39)
  Match dscp af21 (18) af22 (20) af23 (22)

Class Map match-any AVB-SR-CLASS-B (id 42)
  Match cos 2

Class Map match-any AVB-SR-CLASS-A (id 41)
  Match cos 3

Class Map match-any AVB-SCAVENGER-DATA-CLASS (id 35)
  Match access-group name AVB-SCAVENGER-DATA-CLASS-ACL

Class Map match-any AVB-CONTROL-MGMT-QUEUE (id 43)
  Match ip dscp cs2 (16)
  Match ip dscp cs3 (24)
  Match ip dscp cs6 (48)
  Match ip dscp cs7 (56)
  Match ip precedence 6
  Match ip precedence 7
  Match ip precedence 3
  Match ip precedence 2
  Match cos 6
  Match cos 7

```

---

This example shows how you can view all the class-map configuration details when AVB is disabled.

```

Device#show class-map

Building configuration...

Current configuration : 2650 bytes
!
class-map match-any AVB-VOIP-DATA-CLASS
match dscp ef
  match cos 5
class-map match-any AVB-BULK-DATA-CLASS
match access-group name AVB-BULK-DATA-CLASS-ACL
class-map match-any AVB-VOIP-PRIORITY-QUEUE
match dscp cs4 cs5 ef
  match precedence 4 5
  match cos 5
class-map match-any AVB-MULTIMEDIA-CONF-CLASS
match access-group name AVB-MULTIMEDIA-CONF-CLASS-ACL
class-map match-any AVB-SIGNALING-CLASS

```

```

match access-group name AVB-SIGNALING-CLASS-ACL
class-map match-any AVB-MULTIMEDIA-CONF-STREAMING-QUEUE
match dscp af41 af42 af43
  match dscp af31 af32 af33
  match cos 4
class-map match-any AVB-BULK-SCAVENGER-DATA-QUEUE
match dscp cs1 af11 af12 af13
  match precedence 1
  match cos 1
class-map match-any AVB-TRANSACTIONAL-DATA-CLASS
match access-group name AVB-TRANSACTIONAL-DATA-CLASS-ACL
class-map match-any AVB-TRANSACTIONAL-DATA-QUEUE
match dscp af21 af22 af23
class-map match-any AVB-SCAVENGER-DATA-CLASS
match access-group name AVB-SCAVENGER-DATA-CLASS-ACL
end

```

---

This example shows how you can view all the AVB QoS statistics.

```
Device#show policy-map interface gigabitEthernet 1/0/15
```

```
GigabitEthernet1/0/15
```

```
Service-policy input: AVB-Input-Policy-Remark-AB
```

```

Class-map: AVB-SR-CLASS-A (match-any)
  0 packets
  Match: cos 3
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    cos 0

```

```

Class-map: AVB-SR-CLASS-B (match-any)
  0 packets
  Match: cos 2
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    cos 0

```

```

Class-map: class-default (match-any)
  0 packets
  Match: any

```

```
Service-policy : AVB-Input-Child-Policy
```

```

Class-map: AVB-VOIP-DATA-CLASS (match-any)
  0 packets
  Match: dscp ef (46)

```

```
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: cos 5
    0 packets, 0 bytes
    5 minute rate 0 bps
QoS Set
    cos 3

Class-map: AVB-MULTIMEDIA-CONF-CLASS (match-any)
    0 packets
Match: access-group name AVB-MULTIMEDIA-CONF-CLASS-ACL
    0 packets, 0 bytes
    5 minute rate 0 bps
QoS Set
    dscp af41

Class-map: AVB-BULK-DATA-CLASS (match-any)
    0 packets
Match: access-group name AVB-BULK-DATA-CLASS-ACL
    0 packets, 0 bytes
    5 minute rate 0 bps
QoS Set
    dscp af11

Class-map: AVB-TRANSACTIONAL-DATA-CLASS (match-any)
    0 packets
Match: access-group name AVB-TRANSACTIONAL-DATA-CLASS-ACL
    0 packets, 0 bytes
    5 minute rate 0 bps
QoS Set
    dscp af21

Class-map: AVB-SCAVENGER-DATA-CLASS (match-any)
    0 packets
Match: access-group name AVB-SCAVENGER-DATA-CLASS-ACL
    0 packets, 0 bytes
    5 minute rate 0 bps
QoS Set
    dscp cs1

Class-map: AVB-SIGNALING-CLASS (match-any)
    0 packets
Match: access-group name AVB-SIGNALING-CLASS-ACL
    0 packets, 0 bytes
    5 minute rate 0 bps
QoS Set
    dscp cs3

Class-map: class-default (match-any)
    0 packets
Match: any
```

```
QoS Set
  dscp default
```

```
Service-policy output: AVB-Output-Policy-Default
```

```
queue stats for all priority classes:
  Queueing
  priority level 3

  (total drops) 0
  (bytes output) 7595
```

```
queue stats for all priority classes:
  Queueing
  priority level 2

  (total drops) 0
  (bytes output) 0
```

```
queue stats for all priority classes:
  Queueing
  priority level 1

  (total drops) 0
  (bytes output) 0
```

```
Class-map: AVB-SR-CLASS-A (match-any)
  0 packets
  Match: cos 3
    0 packets, 0 bytes
    5 minute rate 0 bps
  Priority: 1% (10000 kbps), burst bytes 250000,

  Priority Level: 1
```

```
Class-map: AVB-SR-CLASS-B (match-any)
  0 packets
  Match: cos 2
    0 packets, 0 bytes
    5 minute rate 0 bps
  Priority: 1% (10000 kbps), burst bytes 250000,

  Priority Level: 2
```

```
Class-map: AVB-CONTROL-MGMT-QUEUE (match-any)
  0 packets
  Match: ip dscp cs2 (16)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: ip dscp cs3 (24)
    0 packets, 0 bytes
```

```

    5 minute rate 0 bps
Match: ip dscp cs6 (48)
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: ip dscp cs7 (56)
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: ip precedence 6
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: ip precedence 7
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: ip precedence 3
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: ip precedence 2
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: cos 6
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: cos 7
    0 packets, 0 bytes
    5 minute rate 0 bps
Priority: 15% (150000 kbps), burst bytes 3750000,

Priority Level: 3

Class-map: class-default (match-any)
  0 packets
  Match: any
  Queueing

  (total drops) 0
  (bytes output) 0
  bandwidth remaining 80%
  queue-buffers ratio 70

Service-policy : AVB-Output-Child-Policy

Class-map: AVB-VOIP-PRIORITY-QUEUE (match-any)
  0 packets
  Match: dscp cs4 (32) cs5 (40) ef (46)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: precedence 4 5
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 5
    0 packets, 0 bytes

```



```
    5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 30%
queue-buffers ratio 30

Class-map: AVB-MULTIMEDIA-CONF-STREAMING-QUEUE (match-any)
  0 packets
  Match: dscp af41 (34) af42 (36) af43 (38)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: dscp af31 (26) af32 (28) af33 (30)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 4
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing

  queue-limit dscp 26 percent 80
  queue-limit dscp 28 percent 90
  queue-limit dscp 34 percent 80
  queue-limit dscp 36 percent 90
  (total drops) 0
  (bytes output) 0
  bandwidth remaining 15%

  queue-buffers ratio 15

Class-map: AVB-TRANSACTIONAL-DATA-QUEUE (match-any)
  0 packets
  Match: dscp af21 (18) af22 (20) af23 (22)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 0
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing

  queue-limit dscp 18 percent 80
  queue-limit dscp 20 percent 90
  (total drops) 0
  (bytes output) 0
  bandwidth remaining 15%

  queue-buffers ratio 15

Class-map: AVB-BULK-SCAVENGER-DATA-QUEUE (match-any)
  0 packets
```

```

Match: dscp cs1 (8) af11 (10) af12 (12) af13 (14)
      0 packets, 0 bytes
      5 minute rate 0 bps
Match: precedence 1
      0 packets, 0 bytes
      5 minute rate 0 bps
Match: cos 1
      0 packets, 0 bytes
      5 minute rate 0 bps
Queueing

queue-limit dscp 8 percent 80
queue-limit dscp 10 percent 80
queue-limit dscp 12 percent 90
(total drops) 0
(bytes output) 0
bandwidth remaining 15%

queue-buffers ratio 15

Class-map: class-default (match-any)
  0 packets
  Match: any
  Queueing

  (total drops) 0
  (bytes output) 0
  bandwidth remaining 25%
  queue-buffers ratio 25

```

The following is a sample output from the **show platform hardware fed switch active qos queue config interface interface-id** command.

```

Device#show platform hardware fed switch active qos queue config interface t1/0/11
DATA Port:2 GPN:11 AFD:Disabled QoSMap:2 HW Queues: 16 - 23
  DrainFast:Disabled PortSoftStart:1 - 3600

```

```

-----
      DTS   Hardmax   Softmax   PortSMin   GlblSMin   PortStEnd
-----
0  0  9    33    3    33    0    0    0    0    1  4800
1  0  9    33    4  2400   99   99    0    0    1  4800
2  1  6    30    4  2400   90   90    0    0    1  4800
3  1  5     0    4  2400  189  189   63   63    1  4800
4  1  5     0    4  2400   90   90   30   30    1  4800
5  1  5     0    4  2400   90   90   30   30    1  4800
6  1  5     0    4  2400   90   90   30   30    1  4800
7  1  5     0    4  2400  153  153   51   51    1  4800
Priority   Shaped/shared   weight   shaping_step
-----
0         1     Shaped         16383         163
1         2     Shaped         16383         163

```

2	3	Shaped	125	153
3	7	Shared	50	0
4	7	Shared	100	0
5	7	Shared	100	0
6	7	Shared	100	0
7	7	Shared	60	0

The following is a sample output from the **show platform hardware fed switch active qos queue stats interface interface-id** command.

```
Device#show platform hardware fed switch active qos queue stats interface t1/0/15
DATA Port:8 Enqueue Counters
```

```
-----
Queue Buffers Enqueue-TH0 Enqueue-TH1 Enqueue-TH2
-----
0          1           0           0 23788459506
1          0           0           0 30973507838
2          0           0 12616270   13164040
3          0           0           0           0
4          0           0           0           0
5          0           0           0           0
6          0           0           0           0
7          0           0           0 119616
```

```
DATA Port:8 Drop Counters
```

```
-----
Queue Drop-TH0 Drop-TH1 Drop-TH2 SBufDrop QebDrop
-----
0          0           0           0           0           0
1          0           0           0           0           0
2          0           0           0           0           0
3          0           0           0           0           0
4          0           0           0           0           0
```

## Examples for MVRP

This example shows how you can view the MVRP summary information.

```
Device#show mvrp summary
```

```
MVRP global state           : enabled
MVRP VLAN creation          : enabled
VLANs created via MVRP      : 2,567
MAC learning auto provision : disabled
Learning disabled on VLANs  : none
```

This example shows how you can view the interface MVRP information.

```
Device#show mvrp interface
```

Port	Status	Registrar	State		
Tel/0/47	on		normal		
Tel/1/3	off		normal		
Port	Join Timeout	Leave Timeout	Leaveall Timeout	Periodic	
				Timeout	
Tel/0/47	20	60	1000	100	
Tel/1/3	20	60	1000	100	
Port	Vlans Declared				
Tel/0/47	1-2,567,900				
Tel/1/3	none				
Port	Vlans Registered				
Tel/0/47	2,567				
Tel/1/3	none				
Port	Vlans Registered and in Spanning Tree Forwarding State				
Tel/0/47	2,567				
Tel/1/3	none				

## Feature Information for AVB

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

**Table 1: Feature Information for AVB**

Releases	Modification
Cisco IOS XE Everest 16.5.1a	Support for AVB was enabled on WS-C3650-8X24UQ and WS-C3650-12X48UQ switch models.
Cisco IOS XE Denali 16.3.2	Enhanced to support hierarchical QoS, which provides a two level parent-child policy. Support for AVB was enabled on mGig interfaces of the WS-3850-12X48U and WS-C3850-24XU.
Cisco IOS XE Denali 16.3.1	This feature was introduced.



PART **II**

## Campus Fabric

- [Campus Fabric, on page 41](#)





## CHAPTER 2

# Campus Fabric

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- [Information About Campus Fabric, on page 41](#)

## Information About Campus Fabric

Campus Fabric provides the basic infrastructure for building virtual networks based on policy-based segmentation constructs. This module describes how to configure Campus Fabric on your device.

## Campus Fabric Overview

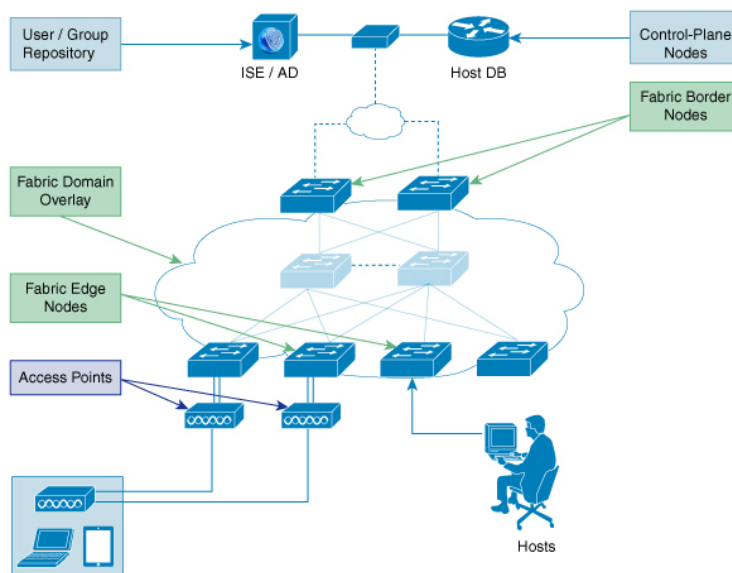
Campus Fabric Overlay provisioning consists of three main components:

- Control-Plane
- Data-Plane
- Policy-Plane

## Understanding Fabric Domain Elements

[Figure 3: Elements of a Fabric Domain](#) displays the elements that make up the fabric domain.

Figure 3: Elements of a Fabric Domain



The following is a description of the fabric domain elements illustrated in the [Figure 3: Elements of a Fabric Domain](#).

- **Fabric Edge Devices**—Provide connectivity to users and devices that connect to the fabric domain. Fabric edge devices identify and authenticate end points, and register end-point ID information in the fabric host-tracking database. These devices encapsulate at ingress and decapsulate at egress, to forward traffic to and from the end points connected to the fabric domain.
- **Fabric Control-Plane Devices**—Provide overlay reachability information and end points-to-routing locator mapping, in the host-tracking database. A control-plane device receives registrations from fabric edge devices having local end points, and resolves requests from edge devices to locate remote end points. You can configure up to three control-plane devices-internally (a fabric border device) and externally (a designated control-plane device, such as Cisco CSR1000v), to allow redundancy in your network.
- **Fabric Border Devices** — Connect traditional Layer 3 networks or different fabric domains to the local domain, and translate reachability and policy information, such as virtual routing and forwarding (VRF) and SGT information, from one domain to another.
- **Virtual Contexts**—Provide virtualization at the device level, using VRF to create multiple instances of Layer 3 routing tables. Contexts or VRFs provide segmentation across IP addresses, allowing for overlapped address space and traffic separation. You can configure up to 32 contexts in the fabric domain.
- **Host-Pools**—Group end points that are present in the fabric domain into IP pools, and identify them with a VLAN ID and an IP subnet.

## Campus Fabric Configuration Guidelines

Consider the following guidelines and limitations when configuring campus fabric elements:

- Configure no more than 3 control-plane devices in each fabric domain.
- Each fabric edge device supports up to 2000 hosts.
- Each control-plane device supports up to 5000 fabric edge device registrations.



- Configure no more than 32 virtual contexts in each fabric domain.

## How to Configure Fabric Overlay

### Configuring Fabric Edge Devices

Follow these steps to configure fabric edge devices:

#### Before you begin

Configure a loopback0 IP address for each edge device to ensure that the device is reachable. Ensure that you run the `ip lisp source-locator loopback0` command on the uplink interface.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>fabric auto</b> <b>Example:</b> Device (config) # <b>fabric auto</b>	Enables automatic fabric provisioning and enters automatic fabric configuration mode.
<b>Step 4</b>	<b>domain {default   name <i>fabric domain name</i>}</b> <b>Example:</b> Device (config-fabric-auto) # <b>domain default</b> Device (config-fabric-auto) # <b>domain name <i>exampledomain</i></b>	Configures the default fabric domain and enters domain configuration mode. The <b>name</b> keyword allows you to add a new fabric domain. The <b>no</b> version of this command deletes the fabric domain. You can configure either the default domain, or create a new fabric domain and not both.
<b>Step 5</b>	<b>control-plane <i>ipv4 address</i> <b>auth_key</b> <i>key</i></b> <b>Example:</b> Device (config-fabric-auto-domain) # <b>control-plane <i>198.51.100.2</i> <b>auth_key</b> <i>examplekey123</i></b>	Configures the control-plane device IP address and the authentication key, to allow the fabric edge device to communicate with the control-plane device.  The <b>no control-plane <i>control-plane ipv4 address</i> <b>auth_key</b> <i>key</i></b> command deletes the control-plane device from the fabric domain. You can specify up to 3 control-plane IP addresses for the edge device.

	Command or Action	Purpose
<b>Step 6</b>	<b>border</b> <i>ipv4 address</i> <b>Example:</b> Device (config-fabric-auto-domain) # <b>border</b> <b>198.51.100.4</b>	Configures the IP address of the fabric border device, to allow the fabric edge device to communicate with the fabric border device. You can specify up to 2 border IP addresses for the edge device.
<b>Step 7</b>	<b>context name</b> <i>name id ID</i> <b>Example:</b> Device (config-fabric-auto-domain) # <b>context</b> <b>name eg-context</b> <b>id 10</b>	Creates a new context in the fabric domain and assigns an ID to it. Contexts or VRFs provide segmentation across IP addresses, allowing for overlapped address space and traffic separation. You can configure up to 32 contexts in the fabric domain. This step is mandatory if you want to associate a context to a host-pool.
<b>Step 8</b>	<b>host-pool name</b> <i>name</i> <b>Example:</b> Device (config-fabric-auto-domain) # <b>host-pool</b> <b>name VOICE_DOMAIN</b>	Creates an IP pool to group endpoints in the fabric domain, and enters host-pool configuration mode.
<b>Step 9</b>	<b>host-vlan</b> <i>ID</i> <b>Example:</b> Device (config-fabric-auto-domain-host-pool) # <b>host-vlan</b> <b>10</b>	Configures a VLAN ID to associate with the host-pool.
<b>Step 10</b>	<b>context name</b> <i>name</i> <b>Example:</b> Device (config-fabric-auto-domain-host-pool) # <b>context</b> <b>name</b> <b>eg-context</b>	(Optional) Associates a context or a VRF with the host-pool. You can configure up to 32 contexts in your fabric domain.
<b>Step 11</b>	<b>gateway</b> <i>IP address/ mask</i> <b>Example:</b> Device (config-fabric-auto-domain-host-pool) # <b>gateway</b> <b>192.168.1.254/24</b>	Configures the routing gateway IP address and the subnet mask for the host-pool. This address and subnet mask are used to map the endpoint to the uplink interface connecting to the underlay.
<b>Step 12</b>	<b>use-dhcp</b> <i>IP address</i> <b>Example:</b> Device (config-fabric-auto-domain-host-pool) # <b>use-dhcp</b> <b>172.10.1.1</b>	Configures a DHCP server address for the host-pool. You can configure multiple DHCP addresses for your host-pool. To delete a DHCP server address, use the <b>no use-dhcp IP address</b> command.
<b>Step 13</b>	<b>exit</b> <b>Example:</b> Device (config-fabric-auto-domain) # <b>exit</b>	

	Command or Action	Purpose
<b>Step 14</b>	<b>show fabric domain</b> <b>Example:</b> Device# <b>show fabric domain</b>	Displays your fabric domain configuration. As part of this configuration, additional CLI commands are generated automatically. For more information, see <a href="#">Auto-Configured Commands on Fabric Edge Devices</a>

### Auto-Configured Commands on Fabric Edge Devices

As a part of Fabric Overlay provisioning, some LISP-based configuration, SGT (security group tag) configuration and EID to RLOC mapping configuration is auto-generated, and is displayed in your running configuration.

For example, consider this configuration scenario for an edge device (loopback address 2.1.1.1/32):

```
device(config)#fabric auto
device(config-fabric-auto)#domain default
device(config-fabric-auto-domain)#control-plane 192.168.1.4 auth-key example-key1
device(config-fabric-auto-domain)#control-plane 192.168.1.5 auth-key example-key2
device(config-fabric-auto-domain)#border 192.168.1.6
device(config-fabric-auto-domain)#context name example-context ID 10
device(config-fabric-auto-domain)#host-pool name VOICE_DOMAIN
device(config-fabric-auto-domain-host-pool)#vlan 10
device(config-fabric-auto-domain-host-pool)#context example-context
device(config-fabric-auto-domain-host-pool)#gateway 192.168.1.254/24
device(config-fabric-auto-domain-host-pool)#use-dhcp 209.165.201.6
```

This is sample output for your fabric edge configuration:

```
device#show running-config
router lisp
encapsulation vxlan
locator-set default.RLOC
IPv4-interface Loopback0 priority 10 weight 10
exit
!
eid-table default instance-id 0
exit
!
eid-table vrf example-context instance-id 10
dynamic-eid example-context.EID.VOICE_DOMAIN
database-mapping 192.168.1.0/24 locator-set default.RLOC
exit
!
exit
!
loc-reach-algorithm lsb-reports ignore
disable-ttl-propagate
ipv4 sgt
ipv4 use-petr 192.168.1.6 priority 10 weight 10
ipv4 itr map-resolver 192.168.1.4
ipv4 itr map-resolver 192.168.1.5
ipv4 itr
ipv4 etr map-server 192.168.1.4 key example-key1
ipv4 etr map-server 192.168.1.5 key example-key2
ipv4 etr
exit
!
```

## Configuring Fabric Control-Plane Devices

Follow these steps to configure your control-plane device.

### Before you begin

Configure a loopback0 IP address for each edge device to ensure that the device is reachable. Ensure that you run the `ip lisp source-locator loopback0` command on the uplink interface.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>fabric auto</b> <b>Example:</b> Device (config) # <code>fabric auto</code>	Enables automatic fabric provisioning and enters automatic fabric configuration mode.
<b>Step 4</b>	<b>domain { default   name <i>fabric domain name</i> }</b> <b>Example:</b> Device (config-fabric-auto) # <code>domain default</code> Device (config-fabric-auto) # <code>domain name example-domain</code>	Configures the default fabric domain and enters domain configuration mode. The <b>name</b> keyword allows you to add a new fabric domain.
<b>Step 5</b>	<b>control-plane self auth_key <i>key</i></b> <b>Example:</b> Device (config-fabric-auto-domain) # <code>control-plane self auth_key example-key1</code>	Enables the control-plane service with the authentication key, for the configured host-prefix.
<b>Step 6</b>	<b>host-prefix <i>prefix</i> context name <i>name</i> id <i>ID</i></b> <b>Example:</b> Device (config-fabric-auto-domain) # <code>host-prefix 192.168.1.0/24 context name example-context id 10</code>	Creates a new context or a VRF and assigns an ID to it. If you don't specify a context, the default context is used.
<b>Step 7</b>	<b>exit</b> <b>Example:</b> Device (config-fabric-auto-domain) # <code>exit</code>	

	Command or Action	Purpose
<b>Step 8</b>	<b>show fabric domain</b> <b>Example:</b> Device# <code>show fabric domain</code>	Displays your control-plane device configuration. As part of this configuration, additional CLI commands are automatically generated.

## Configuring Fabric Border Devices

Follow these steps to configure your device as a fabric border device.

### Before you begin

Configure a loopback0 IP address for each edge device to ensure that the device is reachable. Ensure that you run the `ip lisp source-locator loopback0` command on the uplink interface.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>fabric auto</b> <b>Example:</b> Device (config)# <code>fabric auto</code>	Enables automatic fabric provisioning and enters automatic fabric configuration mode.
<b>Step 4</b>	<b>domain { default   name fabric domain name}</b> <b>Example:</b> Device (config-fabric-auto)# <code>domain default</code> Device (config-fabric-auto)# <code>domain name exampledomain</code>	Configures the default fabric domain and enters domain configuration mode. The <b>name</b> keyword allows you to add a new fabric domain.
<b>Step 5</b>	<b>control-plane ipv4 address auth_key key</b> <b>Example:</b> Device (config-fabric-auto-domain)# <code>control-plane 198.51.100.2 auth_key example-key1</code>	Configures the IP address and the authentication key of the control-plane device, to allow the fabric border device to communicate with the control-plane device.

	Command or Action	Purpose
<b>Step 6</b>	<b>border self</b> <b>Example:</b> Device (config-fabric-auto-domain) # <b>border self</b>	Enables the device as a fabric border device.
<b>Step 7</b>	<b>context name name idID</b> <b>Example:</b> Device (config-fabric-auto-domain) # <b>context name example-nh id 10</b>	Creates a new context or VRF and assigns a new ID to it. If you don't configure a context, the default context is used.
<b>Step 8</b>	<b>host-prefix prefix context name name</b> <b>Example:</b> Device (config-fabric-auto-domain) # <b>host-prefix 192.168.1.0/24</b> <b>context name eg-context</b>	Creates a host-prefix or a subnet mask with the context.
<b>Step 9</b>	<b>exit</b> <b>Example:</b> Device (config-fabric-auto-domain) # <b>exit</b>	
<b>Step 10</b>	<b>show fabric domain</b> <b>Example:</b> Device# <b>show fabric domain</b>	Displays your fabric border device configuration.

## Security Group Tags and Policy Enforcement in Campus Fabric

Campus Fabric overlay propagates source group tags (SGTs) across devices in the fabric domain. Packets are encapsulated using virtual extensible LAN (VXLAN) and carry the SGT information in the header. When you configure an edge device, the `ipv4 sgt` command is auto-generated. The SGT mapped to the IP address of the edge device is carried within the encapsulated packet and propagated to the destination device, where the packet is decapsulated and the Source Group Access Control List (SGACL) policy is enforced.

For more information on Cisco TrustSec and Source Group Tags, see the [Cisco TrustSec Switch Configuration Guide](#)

## Multicast Using Campus Fabric Overlay

You can use Campus Fabric overlay to carry multicast traffic over core networks that do not have native multicast capabilities. Campus Fabric overlay allows unicast transport of multicast traffic with head-end replication in the edge device.



**Note** Only Protocol Independent Multicast (PIM) Sparse Mode and PIM Source Specific Multicast (SSM) are supported in Campus Fabric; dense mode is not supported.

## Configuring Multicast PIM Sparse Mode in Campus Fabric

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip multicast-routing</b> <b>Example:</b> Device (config)#ip multicast-routing	Enables IP multicast routing.
<b>Step 4</b>	<b>ip pim rp-address</b> <i>rp address</i> <b>Example:</b> Device (config)#ip pim rp-address 10.1.0.2	Statically configures the address of a Protocol Independent Multicast (PIM) rendezvous point (RP) for multicast groups.
<b>Step 5</b>	<b>interface LISP</b> <i>interface number</i> <b>Example:</b> Device (config)#interface LISP 0	Specifies the LISP interface and the subinterface on which to enable Protocol Independent Multicast (PIM) sparse mode.
<b>Step 6</b>	<b>ip pim sparse-mode</b> <b>Example:</b> Device (config-if)#ip pim sparse-mode	Enables Protocol Independent Multicast (PIM) on the interface for sparse-mode operation.
<b>Step 7</b>	<b>exit</b> <b>Example:</b> Device (config-if)#exit	Exits interface configuration mode and enters global configuration mode.
<b>Step 8</b>	<b>interface</b> <i>interface type</i> <i>interface number</i> <b>Example:</b> Device (config)#interface GigabitEthernet0/0/0	Configures the interface facing the endpoint, and enters interface configuration mode.
<b>Step 9</b>	<b>ip pim sparse-mode</b> <b>Example:</b> Device (config-if)#ip pim sparse-mode	Enables Protocol Independent Multicast (PIM) on interface facing the fabric domain for sparse-mode operation.

	Command or Action	Purpose
Step 10	<code>end</code>	Ends the current configuration session and returns to privileged EXEC mode.
Step 11	<code>show ip mroute <i>multicast ip-address</i></code>	Verifies the multicast routes on the device.
Step 12	<code>ping <i>multicast ip-address</i></code>	Verifies basic multicast connectivity by pinging the multicast address.
Step 13	<code>show ip mfib</code>	Displays the forwarding entries and interfaces in the IPv4 Multicast Forwarding Information Base (MFIB)

## Configuring Multicast PIM SSM in Campus Fabric

### Procedure

	Command or Action	Purpose
Step 1	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
Step 2	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
Step 3	<b>ip multicast-routing</b> <b>Example:</b> Device(config)# <code>ip multicast-routing</code>	Enables IP multicast routing.
Step 4	<b>ip pim ssm {default   range {  <i>access-list-number</i>   <i>access-list-name</i></b> <b>Example:</b> Device(config)# <code>ip pim ssm default</code>	Defines the Source Specific Multicast (SSM) range of IP multicast addresses.
Step 5	<b>interface LISP <i>interface number</i></b> <b>Example:</b> Device(config)# <code>interface LISP 0</code>	Specifies the LISP interface and the subinterface on which to enable Protocol Independent Multicast (PIM) sparse mode.
Step 6	<b>ip pim sparse-mode</b> <b>Example:</b> Device(config-if)# <code>ip pim sparse-mode</code>	Enables Protocol Independent Multicast (PIM) on the specified interface for sparse-mode operation.



	Command or Action	Purpose
<b>Step 7</b>	<b>exit</b> <b>Example:</b> Device(config-if)#exit	Exits interface configuration mode and enters global configuration mode.
<b>Step 8</b>	<b>interface</b> <i>interface type interface number</i> <b>Example:</b> Device(config)#interface GigabitEthernet0/0/0	Configures the interface facing the endpoint, and enters interface configuration mode.
<b>Step 9</b>	<b>ip pim sparse-mode</b> <b>Example:</b> Device(config-if)#ip pim sparse-mode	Enables Protocol Independent Multicast (PIM) on interface facing the fabric domain for sparse-mode operation.
<b>Step 10</b>	<b>ip igmp version 3</b> <b>Example:</b> Device(config-if)#ip igmp version 3	Configures IGMP version 3 on the interface.
<b>Step 11</b>	<b>end</b>	Ends the current configuration session and returns to privileged EXEC mode.
<b>Step 12</b>	<b>show ip mroute</b> <i>multicast ip-address</i>	Verifies the multicast routes on the device.
<b>Step 13</b>	<b>ping</b> <i>multicast ip-address</i>	Verifies basic multicast connectivity by pinging the multicast address.
<b>Step 14</b>	<b>show ip mfib</b>	Displays the forwarding entries and interfaces in the IPv4 Multicast Forwarding Information Base (MFIB)

## Data Plane Security in Campus Fabric

Campus Fabric Data Plane Security ensures that only traffic from within a fabric domain can be decapsulated, by an edge device at the destination. Edge and border devices in the fabric domain validate that the source Routing Locator (RLOC), or the uplink interface address, carried by the data packet is a member of the fabric domain.

Data Plane Security ensures that the edge device source addresses in the encapsulated data packets cannot be spoofed. Packets from outside the fabric domain carry invalid source RLOCs that are blocked during decapsulation by edge and border devices.

### Configuring Data Plane Security on Edge Devices

#### Before you begin

- Configure a loopback0 IP address for each edge device to ensure that the device is reachable.  
Ensure that you apply the **ip lisp source-locator loopback0** command to the uplink interface.
- Ensure that your underlay configuration is set up.

- Ensure that you have configured edge, control-plane, and border devices.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>router lisp</b> <b>Example:</b> Device(config)# <b>router lisp</b>	Enters LISP configuration mode.
<b>Step 3</b>	<b>decapsulation filter rloc source member</b> <b>Example:</b> Device(config-router-lisp)# <b>decapsulation filter rloc source member</b>	Enables the validation of the source RLOC (uplink interface) addresses of encapsulated packets in the fabric domain.
<b>Step 4</b>	<b>exit</b> <b>Example:</b> Device(config-router-lisp)# <b>exit</b>	Exits LISP configuration mode and returns to global configuration mode.
<b>Step 5</b>	<b>show lisp [session [established]   vrf [vrf-name [session [peer-address]]]]</b> <b>Example:</b> Device# <b>show lisp session</b>	Displays reliable transport session information. If there is more than one transport session, the corresponding information is displayed.
<b>Step 6</b>	<b>show lisp decapsulation filter [IPv4-rloc-address   IPv6-rloc-address] [eid-table eid-table-vrf   instance-id iid]</b> <b>Example:</b> Device# <b>show lisp decapsulation filter instance-id 0</b>	Displays RLOC address configuration details (whether manually configured or discovered) on the edge device.

## Configuring Data Plane Security on Control Plane Devices

### Before you begin

- Configure a loopback0 IP address for each control plane device to ensure that the device is reachable. Ensure that you apply the **ip lisp source-locator loopback0** command to the uplink interface.
- Ensure that your underlay configuration is set up.
- Ensure that you have configured edge, control-plane, and border devices.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>router lisp</b> <b>Example:</b> <pre>Device(config)# router lisp</pre>	Enters LISP configuration mode.
<b>Step 4</b>	<b>map-server rloc members distribute</b> <b>Example:</b> <pre>Device(config-router-lisp)# map-server rloc members distribute</pre>	Enables the distribution of the list of EID prefixes, to the edge devices in the fabric domain.
<b>Step 5</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-router-lisp)# exit</pre>	Exits LISP configuration mode.
<b>Step 6</b>	<b>show lisp [session [established]   vrf [vrf-name [session [peer-address]]]]</b> <b>Example:</b> <pre>Device# show lisp session</pre>	Displays reliable transport session information. If there is more than one transport session, the corresponding information is displayed.
<b>Step 7</b>	<b>show lisp decapsulation filter [IPv4-rloc-address   IPv6-rloc-address] [eid-table eid-table-vrf   instance-id iid]</b> <b>Example:</b> <pre>Device# show lisp decapsulation filter instance-id 0</pre>	Displays uplink interface address configuration details manually configured or discovered).

## Configuring Data Plane Security on Border Devices

### Before you begin

- Configure a loopback0 IP address for each border device to ensure that the device is reachable. Ensure that you apply the **ip lisp source-locator loopback0** command to the uplink interface.

- Ensure that your underlay configuration is set up.
- Ensure that you have configured edge, control-plane, and border devices.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>router lisp</b> <b>Example:</b> Device(config)# <b>router lisp</b>	Enters LISP configuration mode.
<b>Step 4</b>	<b>decapsulation filter rloc source member</b> <b>Example:</b> Device(config-router-lisp)# <b>decapsulation filter rloc source member</b>	Enables the validation of the source RLOC (uplink interface) addresses of encapsulated packets in the fabric domain.
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config-router-lisp)# <b>exit</b>	Exits LISP configuration mode and returns to global configuration mode.
<b>Step 6</b>	<b>show lisp [session [established]   vrf [vrf-name [session [peer-address]]]]</b> <b>Example:</b> Device# <b>show lisp session</b>	Displays reliable transport session information. If there is more than one transport session, the corresponding information is displayed.
<b>Step 7</b>	<b>show lisp decapsulation filter [IPv4-rloc-address   IPv6-rloc-address] [cid-table eid-table-vrf   instance-id iid]</b> <b>Example:</b> Device# <b>show lisp decapsulation filter instance-id 0</b>	Displays RLOC address configuration details (manually configured or discovered).

## Campus Fabric Configuration Examples

This is sample output for the **show running-configuration** command for an edge configuration:

```
device#show running-config
fabric auto
!
domain default
control-plane 198.51.100.2 auth-key example-key1
border 192.168.1.6
context name eg-context id 10
!
host-pool name VOICE_VLAN
context eg-context
vlan 10
gateway 192.168.1.254/24
use-dhcp 172.10.1.1
exit
exit
router lisp
locator-set default.RLOC
IPv4-interface Loopback0 priority 10 weight 10
exit
!
encapsulation vxlan
eid-table default instance-id 0
exit
!
eid-table vrf eg-context instance-id 10
dynamic-eid eg-context.EID.VOICE_VLAN
database-mapping 192.168.1.0/24 locator-set default.RLOC
exit
!
exit
!
loc-reach-algorithm lsb-reports ignore
disable-ttl-propagate
ipv4 sgt
ipv4 use-petr 192.168.1.6 priority 10 weight 10
ipv4 itr map-resolver 192.168.1.4
ipv4 itr map-resolver 192.168.1.5
ipv4 itr
ipv4 etr map-server 192.168.1.4 key example-key1
ipv4 etr map-server 192.168.1.5 key example-key2
ipv4 etr
exit
```

This is sample output for the **show running-configuration** command for a control-plane configuration:

```
!
fabric auto
domain default
control-plane auth-key example-key1
exit
!
ip vrf eg-context
!
vlan name VOICE_VLAN id 10
interface Vlan 10
ip address 192.168.1.254 255.255.255.0
ip helper-address global 172.10.1.1
no ip redirects
ip local-proxy-arp
ip route-cache same-interface
```

```

no lisp mobility liveness test
lisp mobility default.EID.VOICE_VLAN
router lisp
eid-table default
dynamic-default.EID.VOICE_VLAN
database-mapping 192.168.1.0/24 locator-set FD_DEFAULT.RLOC
router lisp
site FD_Default
authentication-key example-key1
exit
ipv4 map-server
ipv4 map-resolver
exit

```

This is sample output for the **show running-configuration** command for a border device configuration:

```

!fabric auto
!
domain default
control-plane 198.51.100.2 auth-key example-key1
border self
context name eg-context id 10
!
host-prefix 192.168.1.0/24 context name eg-context
!
host-pool name Voice
context eg-context
use-dhcp 172.10.1.1
exit
!
host-pool name doc
exit
exit
exit
router lisp
encapsulation vxlan
loc-reach-algorithm lsb-reports ignore
disable-ttl-propagate
ipv4 sgt
ipv4 proxy-etr
ipv4 proxy-itr 1.1.1.1
ipv4 itr map-resolver 198.51.100.2
ipv4 etr map-server 198.51.100.2 key example-key1
exit

```



## PART **III**

# CleanAir

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## CHAPTER 3

# Cisco CleanAir

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## Prerequisites for CleanAir

You can configure Cisco CleanAir only on CleanAir-enabled access points.

Only Cisco CleanAir-enabled access points using the following access point modes can perform Cisco CleanAir spectrum monitoring:

- **Local**—In this mode, each Cisco CleanAir-enabled access point radio provides air quality and interference detection reports for the current operating channel only.
- **Monitor**—When Cisco CleanAir is enabled in monitor mode, the access point provides air quality and interference detection reports for all monitored channels.

The following options are available:

- **All**—All channels
- **DCA**—Channel selection governed by the DCA list
- **Country**—All channels are legal within a regulatory domain



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**Note** The access point does not participate in AQ HeatMap in Prime Infrastructure.

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- **SE-Connect**—This mode enables a user to connect a Spectrum Expert application running on an external Microsoft Windows XP or Vista PC to a Cisco CleanAir-enabled access point in order to display and

analyze detailed spectrum data. The Spectrum Expert application connects directly to the access point, bypassing the device. An access point in SE-Connect mode does not provide any Wi-Fi, RF, or spectrum data to the device. All CleanAir system functionality is suspended while the AP is in this mode, and no clients are served. This mode is intended for remote troubleshooting only. Up to three active Spectrum Expert connections are possible.

## Restrictions for CleanAir

- Access points in monitor mode do not transmit Wi-Fi traffic or 802.11 packets. They are excluded from radio resource management (RRM) planning and are not included in the neighbor access point list. IDR clustering depends on the device's ability to detect neighboring in-network access points. Correlating interference device detections from multiple access points is limited between monitor-mode access points.
- Monitor Mode access point in slot 2 operates at 2.4 GHz only.
- We recommend a ratio of 1 monitor-mode access point for every 5 local-mode access points; this can vary based on the network design and expert guidance for best coverage.
- Spectrum Expert (Windows XP laptop client) and AP should be pingable, otherwise; it will not work.
- CleanAir is not supported wherein the channel width is 160 MHz.

## Information About Cisco CleanAir

Cisco CleanAir is a solution designed to proactively manage the challenges of a shared wireless spectrum. It allows you to see all the users of a shared spectrum (both native devices and foreign interferers). It also enables the network to act upon this information. For example, you can manually remove the interfering device, or the system can automatically change the channel away from the interference. CleanAir provides spectrum management and Radio Frequency (RF) visibility.

A Cisco CleanAir system consists of CleanAir-enabled access points, Cisco Wireless LAN Controllers, and Cisco Prime Infrastructure. These access points collect information about all the devices that operate in the industrial, scientific, and medical (ISM) bands, identify and evaluate the information as a potential interference source, and forward it to the controller. The controller controls the access points, collects spectrum data, and forwards information to Cisco Prime Infrastructure or a Cisco mobility services engine (MSE) upon request.

Any networking configurations can be performed only on the mobility controller, configurations cannot be performed in the MA mode. However, any radio level CleanAir configurations can be done using mobility anchor.

For every device operating in the unlicensed band, Cisco CleanAir provides information about what it is, where it is, how it is impacting your wireless network, and what actions you or your network should take. It simplifies RF.

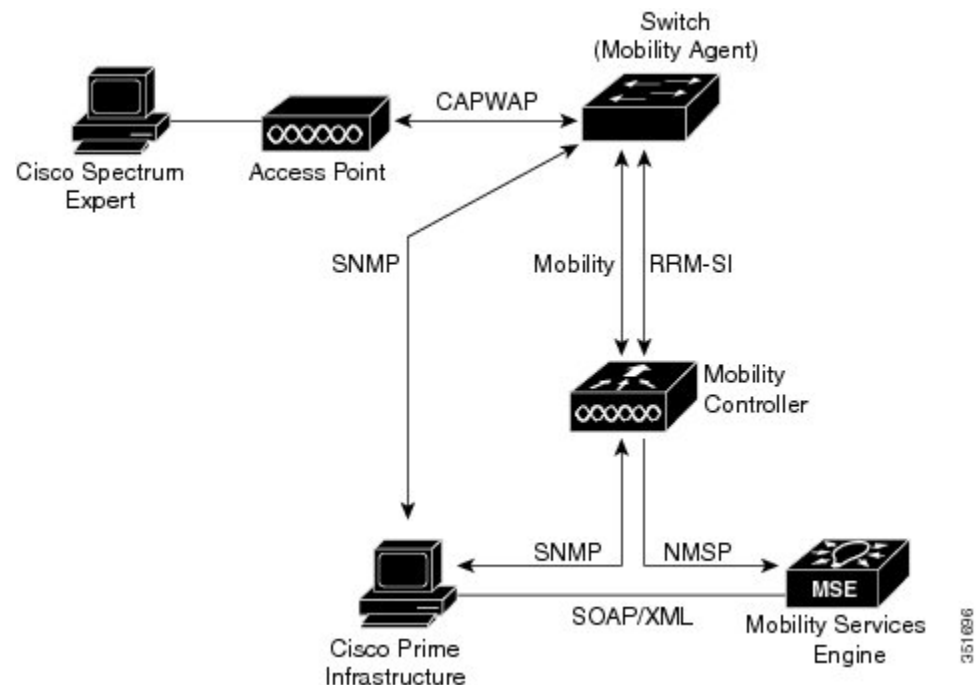
Wireless LAN systems operate in unlicensed 2.4-GHz and 5-GHz ISM bands. Many devices, such as microwave ovens, cordless phones, and Bluetooth devices also operate in these bands and can negatively affect the Wi-Fi operations.

Some of the most advanced WLAN services, such as voice-over-wireless and IEEE 802.11n radio communications, might be significantly impaired by the interference caused by other legal users of the ISM bands. The integration of Cisco CleanAir functionality addresses this problem of RF interference.

## Cisco CleanAir Components

The basic Cisco CleanAir architecture consists of Cisco CleanAir-enabled APs and device. Cisco Prime Infrastructure (PI), Mobility Services Engine (MSE) and Cisco Spectrum Expert are optional system components. Cisco PI and MSE provide user interfaces for advanced spectrum capabilities such as historic charts, tracking interference devices, location services and impact analysis.

**Figure 4: Cisco CleanAir Solution**



An access point equipped with Cisco CleanAir technology collects information about non-Wi-Fi interference sources, processes it, and forwards it to the MA. The access point sends the Air Quality Report (AQR) and Interference Device Report (IDR) to the controller.

The mobility controller (MC) controls and configures CleanAir-capable access points, and collects and processes spectrum data, and provides it to the PI and/or the MSE. The MC provides local user interfaces (GUI and CLI) to configure basic CleanAir features and services and display current spectrum information. The MC also detects, merges, and mitigates interference devices using RRM TPC and DCM. For details, see Interference Device Merging.

Cisco PI provides advanced user interfaces for CleanAir that include feature enabling and configuration, consolidated display information, historic AQ records and reporting engines. PI also shows charts of interference devices, AQ trends, and alerts.

Cisco MSE is required for location and historic tracking of interference devices, and provides coordination and consolidation of interference reports across multiple controllers. MSE also provides adaptive Wireless Intrusion Prevention System (WIPS) service that provides comprehensive over-the-air threat detection, location and mitigation. MSE also merges all the interference data.

To obtain detailed spectrum data that can be used to generate RF analysis plots similar to those provided by a spectrum analyzer, you can configure a Cisco CleanAir-enabled access point to connect directly to a Microsoft Windows XP or Vista PC running the Cisco Spectrum Expert application.

The device performs the following tasks in a Cisco CleanAir system:

- Configures Cisco CleanAir capabilities on the access point.
- Provides interfaces ( CLI, and SNMP) for configuring Cisco CleanAir features and retrieving data.
- Displays spectrum data.
- Collects and processes AQRs from the access point and stores them in the air quality database. AQRs contain information about the total interference from all the identified sources represented by the Air Quality Index (AQI) and the summary for the most severe interference categories. The CleanAir system can also include unclassified interference information under per-interference type reports that enable you to take action in scenarios where interference because of unclassified interfering devices is more.
- Collects and processes IDRs from the access point and stores them in the interference device database.
- Forwards spectrum data to Prime Infrastructure and the MSE.



**Note** In Cisco Catalyst 9800 Series Wireless Controller, when Cisco CleanAir is disabled, both CleanAir and Air Quality reporting are disabled. In spite of this, Air Quality is still populated.

## Cisco CleanAir-Related Terms

*Table 2: CleanAir-Related Terms*

Term	Description
AQI	Air Quality Index. The AQI is an indicator of air quality, based on the air pollutants. An AQI of 0 is bad and an AQI > 85 is good.
AQR	Air Quality Report. AQRs contain information about total interference from all the identified sources represented by AQI and the summary of the most severe interference categories. AQRs are sent every 15 minutes to the Mobility Controller and every 30 seconds in the Rapid mode.
DC	Duty Cycle. Percentage of time that the channel is utilized by a device.
EDRRM	Event-Driven RRM. EDRRM allows an access point in distress to bypass normal RRM intervals and immediately change channels.
IDR	Interference Device Reports that an access point sends to the controller.
ISI	Interference Severity Index. The ISI is an indicator of the severity of the interference.
MA	Mobility Agent. An MA is either an access switch that has a wireless module running on it or an MC with an internal MA running on it. An MA is the wireless component that maintains client mobility state machine for a mobile client that is connected to an access point to the device that the MA is running on.
MC	Mobility Controller. An MC provides mobility management services for inter-peer group roaming events. The MC provides a central point of contact for management and sends the configuration to all the mobility agents under its sub-domain of their mobility configuration, peer group membership and list of members.

Term	Description
RSSI	Received Signal Strength Indicator. RSSI is a measurement of the power present in a received radio signal. It is the power at which an access point sees the interferer device.

## Interference Types that Cisco CleanAir can Detect

Cisco CleanAir can detect interference, report on the location and severity of the interference, and recommend different mitigation strategies. Two such mitigation strategies are persistent device avoidance and spectrum event-driven RRM.

Wi-Fi chip-based RF management systems share these characteristics:

- Any RF energy that cannot be identified as a Wi-Fi signal is reported as noise.
- Noise measurements that are used to assign a channel plan tend to be averaged over a period of time to avoid instability or rapid changes that can be disruptive to certain client devices.
- Averaging measurements reduces the resolution of the measurement. As such, a signal that disrupts clients might not look like it needs to be mitigated after averaging.
- All RF management systems available today are reactive in nature.

Cisco CleanAir is different and can positively identify not only the source of the noise but also its location and potential impact to a WLAN. Having this information allows you to consider the noise within the context of the network and make intelligent and, where possible, proactive decisions. For CleanAir, two types of interference events are common:

- Persistent interference
- Spontaneous interference

Persistent interference events are created by devices that are stationary in nature and have intermittent but largely repeatable patterns of interference. For example, consider the case of a microwave oven located in a break room. Such a device might be active for only 1 or 2 minutes at a time. When operating, however, it can be disruptive to the performance of the wireless network and associated clients. Using Cisco CleanAir, you can positively identify the device as a microwave oven rather than indiscriminate noise. You can also determine exactly which part of the band is affected by the device, and because you can locate it, you can understand which access points are most severely affected. You can then use this information to direct RRM in selecting a channel plan that avoids this source of interference for the access points within its range. Because this interference is not active for a large portion of the day, existing RF management applications might attempt to again change the channels of the affected access points. Persistent device avoidance is unique, however, in that it remains in effect as long as the source of interference is periodically detected to refresh the persistent status. The Cisco CleanAir system knows that the microwave oven exists and includes it in all future planning. If you move either the microwave oven or the surrounding access points, the algorithm updates RRM automatically.




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**Note** Spectrum event-driven RRM can be triggered only by Cisco CleanAir-enabled access points in local mode.

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**Note** All the APs using qualcomm atheros chipset sends air-quality as 100 percent even if the radios detect interference.

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Spontaneous interference is interference that appears suddenly on a network, perhaps jamming a channel or a range of channels completely. The Cisco CleanAir spectrum event-driven RRM feature allows you to set a threshold for air quality (AQ) which, if exceeded, triggers an immediate channel change for the affected access point. Most RF management systems can avoid interference, but this information takes time to propagate through the system. Cisco CleanAir relies on AQ measurements to continuously evaluate the spectrum and can trigger a move within 30 seconds. For example, if an access point detects interference from a video camera, it can recover by changing channels within 30 seconds of the camera becoming active. Cisco CleanAir also identifies and locates the source of interference so that more permanent mitigation of the device can be performed at a later time.

In the case of Bluetooth devices, Cisco CleanAir-enabled access points can detect and report interference only if the devices are actively transmitting. Bluetooth devices have extensive power-save modes. For example, interference can be detected when data or voice is being streamed between the connected devices.

## Interference Device Merging

The Interference Devices (ID) messages are processed on a Mobility Controller (MC). The Mobility Anchor (MA) forwards the ID messages from APs and hence they are processed on the MC. The MC has visibility of the neighbor information across APs connected to different MAs.

ID merging logic requires AP neighbor information. Neighbor information is obtained from the RRM module. This api only gives neighbor information to the APs directly connected to MC.

Currently the AP neighbor list on MA is synced to MC once every 3 minutes; hence the AP neighbor list obtained by this api could be at most 3 mins old. This delay results in delay in merging of Devices as they are discovered. The subsequent periodic merge will pick up the updated neighbor information and merge is performed

## Persistent Devices

Some interference devices such as outdoor bridges and Microwave Ovens only transmit when needed. These devices can cause significant interference to the local WLAN due to short duration and periodic operation remain largely undetected by normal RF management metrics. With CleanAir the RRM DCA algorithm can detect, measure, register and remember the impact and adjust the DCA algorithm. This minimizes the use of channels affected by the persistent devices in the channel plan local to the interference source. Cisco CleanAir detects and stores the persistent device information in the device and this information is used to mitigate interfering channels.

## Persistent Devices Detection

CleanAir-capable Monitor Mode access point collects information about persistent devices on all configured channels and store the information in controller. Local/Bridge mode AP detects interference devices on the serving channels only.

## Persistent Device Avoidance

When a Persistent Device (PD) is detected in the CleanAir module, it is reported to the RRM module on the MA. This information is used in the channel selection by the subsequent EDRRM Event Driven RRM (ED-RRM) signal sent to the RRM module.

## EDRRM and AQR Update Mode

EDRRM is a feature that allows an access point that is in distress to bypass normal RRM intervals and immediately change channels. A CleanAir access point always monitors AQ and reports the AQ every 15 minutes. AQ only reports classified interference devices. The key benefit of EDRRM is very fast action time. If an interfering device is operating on an active channel and causes enough AQ degradation to trigger an EDRRM, then no clients will be able to use that channel or the access point. You must remove the access point from the channel. EDRRM is not enabled by default, you must first enable CleanAir and then enable EDRRM.

AQRs are only available on the MC. The mode configuration and timers are held in Radio Control Block (RCB) on MA (for APs connected to MA). There is no change to the current API available for EMS/NMS. No change is required for directly connected APs as RCB (spectrum config and timers) is available locally. For remote APs (APs connected to MA), three new control messages are added. These three messages are for enable, restart timer and disable rapid update mode for a given AP MAC address and slot.

## CleanAir High Availability

CleanAir configuration (network and radio) is stateful during the switchover. On the MC, Embedded Instrumentation Core (EICORE) provides the sync on network configurations across active and standby nodes. The radio configurations are synced using the HA Infrastructure. The CleanAir configurations on MA are pulled from the MC upon joining. The network configuration is not stored in the EICORE on MA, hence it is synced using HA Infrastructure.

CleanAir Data (AQ and IDR) reports are not stateful, that is, the standby and active nodes are not synced. On switchover, the APs send the reports to the current active slot. The RRM Client (HA Infra Client) is used for CleanAir HA sync.

## How to Configure CleanAir

### Enabling CleanAir for the 2.4-GHz Band (CLI)

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>ap dot11 24ghz cleanair</b> <b>Example:</b> <pre>Device(config)#ap dot11 24ghz cleanair</pre> <pre>Device(config)#no ap dot11 24ghz cleanair</pre>	Enables the CleanAir feature on the 802.11b network. Run the <b>no</b> form of this command to disable CleanAir on the 802.11b network.
<b>Step 3</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring a CleanAir Alarm for 2.4-GHz Air-Quality and Devices

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<b>ap dot11 24ghz cleanair alarm air-quality threshold <i>threshold_value</i></b> <b>Example:</b> <pre>Device(config)#ap dot11 24ghz cleanair alarm air-quality threshold 50</pre>	Configures the alarm for the threshold value for air-quality for all the 2.4-GHz devices. Add the <b>no</b> form of this command to disable the alarm.
<b>Step 3</b>	<b>ap dot11 24ghz cleanair alarm device {bt-discovery   bt-link   canopy   cont-tx   dect-like   fh   inv   jammer   mw-oven   nonstd   report   superag   tdd-tx   video   wimax-fixed   wimax-mobile   xbox   zigbee }</b> <b>Example:</b> <pre>Device(config)#ap dot11 24ghz cleanair alarm device canopy</pre>	Configures the alarm for the 2.4-GHz devices. Add the <b>no</b> form command to disable the alarm. <ul style="list-style-type: none"> <li>• <b>bt-discovery</b>—Bluetooth Discovery.</li> <li>• <b>bt-link</b>—Bluetooth Link.</li> <li>• <b>canopy</b>—Canopy devices.</li> <li>• <b>cont-tx</b>—Continuous Transmitter.</li> <li>• <b>dect-like</b>—Digital Enhanced Cordless Communication (DECT)-like phone.</li> <li>• <b>fh</b>—802.11 frequency hopping devices.</li> <li>• <b>inv</b>—Devices using spectrally inverted WiFi signals.</li> <li>• <b>jammer</b>—Jammer.</li> <li>• <b>mw-oven</b>—Microwave oven.</li> </ul>



	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>nonstd</b>—Devices using non standard Wi-Fi channels.</li> <li>• <b>report</b>—Interference device reporting.</li> <li>• <b>superag</b>—802.11 SuperAG devices.</li> <li>• <b>tdd-tx</b>—TDD Transmitter.</li> <li>• <b>video</b>—Video cameras.</li> <li>• <b>wimax-fixed</b>—WiMax Fixed.</li> <li>• <b>wimax-mobile</b>—WiMax Mobile.</li> <li>• <b>xbox</b>—Xbox.</li> <li>• <b>zigbee</b>—802.15.4 devices.</li> </ul>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring Interference Reporting for a 2.4-GHz Device (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>ap dot11 24ghz cleanair device {bt-discovery   bt-link   canopy   cont-tx   dect-like   fh   inv   jammer   mw-oven   nonstd   report   superag   tdd-tx   video   wimax-fixed   wimax-mobile   xbox   zigbee }</b> <b>Example:</b> Device(config)# <b>ap dot11 24ghz cleanair device bt-discovery</b> Device(config)# <b>ap dot11 24ghz cleanair device bt-link</b> Device(config)# <b>ap dot11 24ghz cleanair device canopy</b> Device(config)# <b>ap dot11 24ghz cleanair</b>	Configures the 2.4-GHz interference devices to report to the device. Run the <b>no</b> form of this command to disable the configuration. The following is a list of the keyword descriptions: <ul style="list-style-type: none"> <li>• <b>bt-discovery</b>—Bluetooth discovery</li> <li>• <b>bt-link</b>—Bluetooth link</li> <li>• <b>canopy</b>—Canopy device</li> <li>• <b>cont-tx</b>—Continuous transmitter</li> <li>• <b>dect-like</b>—Digital Enhanced Cordless Communication-like phone</li> <li>• <b>fh</b>—802.11-frequency hopping device</li> </ul>

	Command or Action	Purpose
	<pre> <b>device cont-tx</b> Device(config)# <b>ap dot11 24ghz cleanair</b> <b>device dect-like</b> Device(config)# <b>ap dot11 24ghz cleanair</b> <b>device fh</b> Device(config)# <b>ap dot11 24ghz cleanair</b> <b>device inv</b> Device(config)# <b>ap dot11 24ghz cleanair</b> <b>device jammer</b> Device(config)# <b>ap dot11 24ghz cleanair</b> <b>device mw-oven</b> Device(config)# <b>ap dot11 24ghz cleanair</b> <b>device nonstd</b> Device(config)# <b>ap dot11 24ghz cleanair</b> <b>device report</b> Device(config)# <b>ap dot11 24ghz cleanair</b> <b>device superag</b> Device(config)# <b>ap dot11 24ghz cleanair</b> <b>device tdd-tx</b> Device(config)# <b>ap dot11 24ghz cleanair</b> <b>device video</b> Device(config)# <b>ap dot11 24ghz cleanair</b> <b>device wimax-fixed</b> Device(config)# <b>ap dot11 24ghz cleanair</b> <b>device wimax-mobile</b> Device(config)# <b>ap dot11 24ghz cleanair</b> <b>device xbox</b> Device(config)# <b>ap dot11 24ghz cleanair</b> <b>device zigbee</b> </pre>	<ul style="list-style-type: none"> <li>• <b>inv</b>—Device using spectrally inverted Wi-Fi signals</li> <li>• <b>jammer</b>—Jammer</li> <li>• <b>mw-oven</b>—Microwave oven</li> <li>• <b>nonstd</b>—Device using nonstandard Wi-Fi channels</li> <li>• <b>report</b>—no description</li> <li>• <b>superag</b>—802.11 SuperAG device</li> <li>• <b>tdd-tx</b>—TDD transmitter</li> <li>• <b>video</b>—Video camera</li> <li>• <b>wimax-fixed</b>—WiMax Fixed</li> <li>• <b>wimax-mobile</b>—WiMax Mobile</li> <li>• <b>xbox</b>—Xbox device</li> <li>• <b>zigbee</b>—802.15.4 device</li> </ul>
<b>Step 3</b>	<pre> <b>end</b> <b>Example:</b> Device(config)# <b>end</b> </pre>	<p>Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.</p>

## Enabling CleanAir for the 5-GHz Band (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ap dot11 5ghz cleanair</b> <b>Example:</b> Device(config)# <code>ap dot11 5ghz cleanair</code> Device(config)# <code>no ap dot11 5ghz cleanair</code>	Enables the CleanAir feature on a 802.11a network. Run the <b>no</b> form of this command to disable CleanAir on the 802.11a network.
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring a CleanAir Alarm for 5-GHz Air-Quality and Devices

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ap dot11 5ghz cleanair alarm air-quality threshold <i>threshold_value</i></b> <b>Example:</b> Device(config)# <code>ap dot11 5ghz cleanair alarm air-quality threshold 50</code>	Configures the alarm for the threshold value for air-quality for all the 5-GHz devices. Add the <b>No</b> form of the command to disable the alarm.
<b>Step 3</b>	<b>ap dot11 5ghz cleanair alarm device {canopy   cont-tx   dect-like   inv   jammer   nonstd   radar   report   superag   tdd-tx   video   wimax-fixed   wimax-mobile}</b> <b>Example:</b> Device(config)# <code>ap dot11 5ghz cleanair alarm device</code>	Configures the alarm for the 5-GHz devices. Add the <b>no</b> form of the command to disable the alarm. <ul style="list-style-type: none"> <li>• <b>canopy</b>—Canopy devices.</li> <li>• <b>cont-tx</b>—Continuous Transmitter.</li> <li>• <b>dect-like</b>—Digital Enhanced Cordless Communication (DECT) like phone.</li> <li>• <b>fh</b>—802.11 frequency hopping devices.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>inv</b>—Devices using spectrally inverted WiFi signals.</li> <li>• <b>jammer</b>—Jammer.</li> <li>• <b>nonstd</b>—Devices using non-standard WiFi channels.</li> <li>• <b>radar</b>—Radars.</li> <li>• <b>report</b>—Interference device reporting.</li> <li>• <b>superag</b>—802.11 SuperAG devices.</li> <li>• <b>tdd-tx</b>—TDD Transmitter.</li> <li>• <b>video</b>—Video cameras.</li> <li>• <b>wimax-fixed</b>—WiMax Fixed.</li> <li>• <b>wimax-mobile</b>—WiMax Mobile.</li> </ul>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring Interference Reporting for a 5-GHz Device (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>ap dot11 5ghz cleanair device{canopy   cont-tx   dect-like   inv   jammer   nonstd   radar   report   superag   tdd-tx   video   wimax-fixed   wimax-mobile}</b> <b>Example:</b> Device(config)# <b>ap dot11 5ghz cleanair device canopy</b> Device(config)# <b>ap dot11 5ghz cleanair device cont-tx</b> Device(config)# <b>ap dot11 5ghz cleanair device dect-like</b>	Configures a 5-GHz interference device to report to the device. Run the <b>no</b> form of this command to disable interference device reporting. The following is a list of the keyword descriptions: <ul style="list-style-type: none"> <li>• <b>canopy</b>—Canopy device</li> <li>• <b>cont-tx</b>—Continuous transmitter</li> <li>• <b>dect-like</b>—Digital Enhanced Cordless Communication-like phone</li> <li>• <b>fh</b>—802.11-frequency hopping device</li> </ul>

	Command or Action	Purpose
	<pre>Device(config)#ap dot11 5ghz cleanair device inv</pre> <pre>Device(config)#ap dot11 5ghz cleanair device jammer</pre> <pre>Device(config)#ap dot11 5ghz cleanair device nonstd</pre> <pre>Device(config)#ap dot11 5ghz cleanair device radar</pre> <pre>Device(config)#ap dot11 5ghz cleanair device report</pre> <pre>Device(config)#ap dot11 5ghz cleanair device superag</pre> <pre>Device(config)#ap dot11 5ghz cleanair device tdd-tx</pre> <pre>Device(config)#ap dot11 5ghz cleanair device video</pre> <pre>Device(config)#ap dot11 5ghz cleanair device wimax-fixed</pre> <pre>Device(config)#ap dot11 5ghz cleanair device wimax-mobile</pre>	<ul style="list-style-type: none"> <li>• <b>inv</b>—Device using spectrally-inverted Wi-Fi signals</li> <li>• <b>jammer</b>—Jammer</li> <li>• <b>nonstd</b>—Device using nonstandard Wi-Fi channels</li> <li>• <b>radar</b>—Radars</li> <li>• <b>report</b>—Interference device reporting</li> <li>• <b>superag</b>—802.11 SuperAG device</li> <li>• <b>tdd-tx</b>—TDD transmitter</li> <li>• <b>video</b>—Video camera</li> <li>• <b>wimax-fixed</b>—WiMax fixed</li> <li>• <b>wimax-mobile</b>—WiMax mobile</li> </ul>
<b>Step 3</b>	<pre>end</pre> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring EDRRM for a CleanAir Event (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<pre>configure terminal</pre> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<pre>ap dot11 {24ghz   5ghz} rrm channel cleanair-event</pre> <p><b>Example:</b></p> <pre>Device(config)#ap dot11 24ghz rrm channel cleanair-event</pre>	Enables EDRRM CleanAir event. Run the <b>no</b> form of this command to disable EDRRM.

	Command or Action	Purpose
	<code>Device(config)#no ap dot11 24ghz rrm channel cleanair-event</code>	
<b>Step 3</b>	<p><code>ap dot11 {24ghz   5ghz} rrm channel cleanair-event [sensitivity {high   low   medium}]</code></p> <p><b>Example:</b></p> <pre>Device(config)#ap dot11 24ghz rrm channel cleanair-event sensitivity high</pre>	<p>Configures the EDRRM sensitivity of the CleanAir event.</p> <p>The following is a list of the keyword descriptions:</p> <ul style="list-style-type: none"> <li>• <b>High</b>—Specifies the most sensitivity to non-Wi-Fi interference as indicated by the AQ value.</li> <li>• <b>Low</b>—Specifies the least sensitivity to non-Wi-Fi interference as indicated by the AQ value.</li> <li>• <b>Medium</b>—Specifies medium sensitivity to non-Wi-Fi interference as indicated by the AQ value.</li> </ul>
<b>Step 4</b>	<p><code>end</code></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	<p>Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.</p>

## Configuring Persistent Device Avoidance

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><code>configure terminal</code></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	<p>Enters global configuration mode.</p>
<b>Step 2</b>	<p><code>ap dot11 {24ghz   5ghz} rrm channel device</code></p> <p><b>Example:</b></p> <pre>Device(config)#ap dot11 24ghz rrm channel device</pre>	<p>Enables the persistent non Wi-Fi device avoidance in the 802.11 channel assignment. Add the <b>no</b> form of the command to disable the persistent device avoidance.</p>
<b>Step 3</b>	<p><code>end</code></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	<p>Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.</p>

# Configuring Cisco CleanAir using the Controller GUI

## Configuring Cisco Spectrum Expert

### Configuring Spectrum Expert (CLI)

#### Before you begin

- Spectrum Expert (Windows XP laptop client) and access point should be pingable, otherwise, it will not work.
- Prior to establishing a connection between the Spectrum Expert console and the access point, make sure that IP address routing is properly configured and the network spectrum interface (NSI) ports are open in any intervening firewalls.
- The access point must be a TCP server listening on ports 37540 for 2.4-GHz and 37550 for 5-GHz frequencies. These ports must be opened for the spectrum expert application to connect to the access point using the NSI protocol.
- You can view the NSI key from the device CLI by using the **show ap name *ap\_name* config dot11 {24ghz | 5ghz}** command.

#### Procedure

---

**Step 1** To configure the access point for SE-Connect mode, enter this command:

```
ap name ap_name mode se-connect
```

**Example:**

```
Device#ap name Cisco_AP3500 mode se-connect
```

**Step 2** When prompted to reboot the access point, enter **Y**.

**Step 3** To view the NSI key for the access point, enter this command:

```
show ap name ap_name config dot11 {24ghz | 5ghz}
```

**Example:**

```
Device#show ap name Cisco_AP3500 config dot11 24ghz
```

```
<snippet>
```

```
CleanAir Management Information
```

```
CleanAir Capable : Yes
CleanAir Management Admin State : Enabled
CleanAir Management Operation State : Up
CleanAir NSI Key : 274F1F9B1A5206683FAF57D87BFFBC9B
CleanAir Sensor State : Configured
```

```
<snippet>
```

---

### What to do next

On the Windows PC, download Cisco Spectrum Expert:

- Access the Cisco Software Center from this URL: <http://www.cisco.com/cisco/software/navigator.html>
- Click **Product > Wireless > Cisco Spectrum Intelligence > Cisco Spectrum Expert > Cisco Spectrum Expert Wi-Fi**, and then download the Spectrum Expert 4.1.11 executable (\*.exe) file.
- Run the Spectrum Expert application on the PC.
- When the Connect to Sensor dialog box appears, enter the IP address of the access point, choose the access point radio, and enter the 16-byte network spectrum interface (NSI) key to authenticate. The Spectrum Expert application opens a TCP/IP connection directly to the access point using the NSI protocol.

When an access point in SE-Connect mode joins a device, it sends a Spectrum Capabilities notification message, and the device responds with a Spectrum Configuration Request. The request contains the 16-byte random NSI key generated by the device for use in NSI authentication. The device generates one key per access point, which the access point stores until it is rebooted.



**Note** You can establish up to three Spectrum Expert console connections per access point radio.

- Verify that the Spectrum Expert console is connected to the access point by selecting the Slave Remote Sensor text box in the bottom right corner of the Spectrum Expert application. If the two devices are connected, the IP address of the access point appears in this text box.
- Use the Spectrum Expert application to view and analyze spectrum data from the access point.

## Verifying CleanAir Parameters

You can verify CleanAir parameters using the following commands:

**Table 3: Commands for verifying CleanAir**

Command Name	Description
show ap dot11 24ghz cleanair air-quality summary	Displays CleanAir AQ data for the 2.4-GHz band.
show ap dot11 24ghz cleanair air-quality worst	Displays CleanAir AQ worst data for the 2.4-GHz band.
show ap dot11 24ghz cleanair config	Displays CleanAir configuration for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type all	Displays all the CleanAir interferers for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type bt-discovery	Displays CleanAir interferers of type BT Discovery for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type bt-link	Displays CleanAir interferers of type BT Link for the 2.4-GHz band.



Command Name	Description
show ap dot11 24ghz cleanair device type canopy	Displays CleanAir interferers of type Canopy for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type cont-tx	Displays CleanAir interferers of type Continuous transmitter for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type dect-like	Displays CleanAir interferers of type DECT Like for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type fh	Displays CleanAir interferers of type 802.11FH for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type inv	Displays CleanAir interferers of type Wi-Fi Inverted for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type jammer	Displays CleanAir interferers of type Jammer for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type mw-oven	Displays CleanAir interferers of type MW Oven for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type nonstd	Displays CleanAir interferers of type Wi-Fi inverted channel for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type persistent	Displays CleanAir interferers of type Persistent for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type superag	Displays CleanAir interferers of type SuperAG for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type tdd-tx	Displays CleanAir interferers of type TDD Transmit for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type video	Displays CleanAir interferers of type Video Camera for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type wimax-fixed	Displays CleanAir interferers of type WiMax Fixed for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type wimax-mobile	Displays CleanAir interferers of type WiMax Mobile for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type xbox	Displays CleanAir interferers of type Xbox for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type zigbee	Displays CleanAir interferers of type Zigbee for the 2.4-GHz band.
show ap dot11 5ghz cleanair air-quality summary	Displays CleanAir AQ data for the 5-GHz band.
show ap dot11 5ghz cleanair air-quality worst	Displays CleanAir AQ worst data for the 5-GHz band.
show ap dot11 5ghz cleanair config	Displays CleanAir configuration for the 5-GHz band.

Command Name	Description
show ap dot11 5ghz cleanair device type all	Displays all the CleanAir interferers for the 5-GHz band.
show ap dot11 5ghz cleanair device type canopy	Displays CleanAir interferers of type Canopy for the 5-GHz band.
show ap dot11 5ghz cleanair device type cont-tx	Displays CleanAir interferers of type Continuous TX for the 5-GHz band.
show ap dot11 5ghz cleanair device type dect-like	Displays CleanAir interferers of type DECT Like for the 5-GHz band.
show ap dot11 5ghz cleanair device type inv	Displays CleanAir interferers of type Wi-Fi Inverted for the 5-GHz band.
show ap dot11 5ghz cleanair device type jammer	Displays CleanAir interferers of type Jammer for the 5-GHz band.
show ap dot11 5ghz cleanair device type nonstd	Displays CleanAir interferers of type Wi-Fi inverted channel for the 5-GHz band.
show ap dot11 5ghz cleanair device type persistent	Displays CleanAir interferers of type Persistent for the 5-GHz band.
show ap dot11 5ghz cleanair device type superag	Displays CleanAir interferers of type SuperAG for the 5-GHz band.
show ap dot11 5ghz cleanair device type tdd-tx	Displays CleanAir interferers of type TDD Transmit for the 5-GHz band.
show ap dot11 5ghz cleanair device type video	Displays CleanAir interferers of type Video Camera for the 5-GHz band.
show ap dot11 5ghz cleanair device type wimax-fixed	Displays CleanAir interferers of type WiMax Fixed for the 5-GHz band.
show ap dot11 5ghz cleanair device type wimax-mobile	Displays CleanAir interferers of type WiMax Mobile for the 5-GHz band.

## Monitoring Interference Devices

When a CleanAir-enabled access point detects interference devices, detections of the same device from multiple sensors are merged together to create clusters. Each cluster is given a unique ID. Some devices conserve power by limiting the transmit time until actually needed, which results in the spectrum sensor to stop detecting the device temporarily. This device is then correctly marked as down. Such a device is correctly removed from the spectrum database. In cases when all the interferer detections for a specific device are reported, the cluster ID is kept alive for an extended period of time to prevent possible device-detection bouncing. If the same device is detected again, it is merged with the original cluster ID and the device-detection history is preserved.

For example, some bluetooth headsets operate on battery power. These devices employ methods to reduce power consumption, such as turning off the transmitter when not actually needed. Such devices can appear

to come and go from the classification. To manage these devices, CleanAir keeps the cluster IDs for longer and they are remerged into a single record upon detection. This process smoothens the user records and accurately represents the device history.

## Configuration Examples for CleanAir

This example shows how to enable CleanAir on the 2.4-GHz band and an access point operating in the channel:

```
Device#configure terminal
Device(config)#ap dot11 24ghz cleanair
Device(config)#exit
Device#ap name TAP1 dot11 24ghz cleanair
Device#end
```

### Configuring a CleanAir Alarm for 2.4-GHz Air-Quality and Devices: Example

This example shows how to configure a CleanAir Alarm for 2.4-GHz Air-Quality threshold of 50 dBm and an Xbox device:

```
Device#configure terminal
Device(config)#ap dot11 24ghz cleanair alarm air-quality threshold 50
Device(config)#ap dot11 24ghz cleanair alarm device xbox
Device(config)#end
```

### Configuring Interference Reporting for 5-GHz Devices: Example

This example shows how to configure interference reporting for 5-GHz devices:

```
Device#configure terminal
Device(config)#ap dot11 5ghz cleanair alarm device xbox
Device(config)#end
```

This example shows how to enable an EDRRM CleanAir event in the 2.4-GHz band and configure high sensitivity to non-Wi-Fi interference:

```
Device#configure terminal
Device(config)#ap dot11 24ghz rrm channel cleanair-event
Device(config)#ap dot11 24ghz rrm channel cleanair-event sensitivity high
Device(config)#end
```

### Configuring Persistent Device Avoidance: Example

This example shows how to enable persistent non Wi-Fi device avoidance in the 2.4-GHz band:

```
Device#configure terminal
Device(config)#ap dot11 24ghz rrm channel device
Device(config)#end
```

### Configuring an Access Point for SE-Connect Mode: Example

This example shows how to configure an access point in the SE-Connect mode:

```
Device#ap name Cisco_AP3500 mode se-connect
```

## CleanAir FAQs

**Q.** How do I check if my MC is up?

**A.** To check if the MC is up, use the command: **show wireless mobility summary**.

This example shows how to display the mobility summary:

```
Device#show wireless mobility summary

Mobility Controller Summary:
Mobility Role                : Mobility Controller
Mobility Protocol Port      : 16666
Mobility Group Name         : MG-AK
Mobility Oracle             : Disabled
Mobility Oracle IP Address  : 0.0.0.0
DTLS Mode                   : Enabled
Mobility Domain ID for 802.11r : 0x39b2
Mobility Keepalive Interval : 10
Mobility Keepalive Count    : 3
Mobility Control Message DSCP Value : 48
Mobility Domain Member Count : 2
Link Status is Control Link Status : Data Link Status
Controllers configured in the Mobility Domain:
IP                Public IP      Group Name      Multicast IP      Link Status
-----
9.6.136.10        -                MG-AK           0.0.0.0           UP      : UP
```

**Q.** Multiple access points detect the same interference device. However, the device shows them as separate clusters or different suspected devices clustered together. Why does this happen?

**A.** Access points must be RF neighbors for the device to consider merging the devices that are detected by these access points. An access point takes time to establish neighbor relationships. A few minutes after the device reboots or after there is a change in the RF group, and similar events, clustering will not be very accurate.

**Q.** Can I merge two monitor-mode access points using a device?

**A.** No, you cannot merge two monitor-mode access points using a device. You can merge the monitor mode access points only using MSE.

**Q.** How do I view neighbor access points?

**A.** To view neighbor access points, use the **show ap ap\_name auto-rf dot11 {24ghz | 5ghz}** command.

This example shows how to display the neighbor access points:

```
Device#show ap name AS-5508-5-AP3 auto-rf dot11 24ghz

<snippet>
Nearby APs
  AP 0C85.259E.C350 slot 0      : -12 dBm on 1 (10.10.0.5)
  AP 0C85.25AB.CCA0 slot 0      : -24 dBm on 6 (10.10.0.5)
  AP 0C85.25C7.B7A0 slot 0      : -26 dBm on 11 (10.10.0.5)
  AP 0C85.25DE.2C10 slot 0      : -24 dBm on 6 (10.10.0.5)
  AP 0C85.25DE.C8E0 slot 0      : -14 dBm on 11 (10.10.0.5)
  AP 0C85.25DF.3280 slot 0      : -31 dBm on 6 (10.10.0.5)
  AP 0CD9.96BA.5600 slot 0      : -44 dBm on 6 (10.0.0.2)
```

```
AP 24B6.5734.C570 slot 0 : -48 dBm on 11 (10.0.0.2)
<snippet>
```

**Q.** What are the debug commands available for CleanAir?

**A.** The debug commands for CleanAir are:

- **debug cleanair** {all | error | event | internal-event | nmsp | packet}
- **debug rrm** {all | channel | detail | error | group | ha | manager | message | packet | power | prealarm | profile | radar | rf-change | scale | spectrum}

**Q.** Why are CleanAir Alarms not generated for interferer devices?

**A.** Verify that the access points are CleanAir-capable and CleanAir is enabled both on the access point and the device.

**Q.** Can the Cisco Catalyst 3850 Series Switches function as a Mobility Agent (MA)?

**A.** Yes, the Cisco Catalyst 3850 Series Switches can function as an MA.

**Q.** Are CleanAir configurations available on the MA?

**A.** From Release 3.3 SE, CleanAir configurations are available on the MA. You can use the following two CleanAir commands on the MA:

- **show ap dot11 5ghz cleanair config**
- **show ap dot11 24ghz cleanair config**

## Additional References

### Related Documents

Related Topic	Document Title
CleanAir commands and their details	<i>CleanAir Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>
High Availability configurations	<i>High Availability Configuration Guide, Cisco IOS XE Release 3SE (Cisco 5700 Series Wireless Controllers)</i>
High Availability commands and their details	<i>High Availability Command Reference, Cisco IOS XE Release 3SE (Cisco 5700 Series Wireless Controllers)</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>



## CHAPTER 4

# Bluetooth Low Energy

- [Information About Bluetooth Low Energy, on page 81](#)
- [Enabling Bluetooth Low Energy Beacon, on page 82](#)

## Information About Bluetooth Low Energy

Bluetooth low energy (BLE) is a wireless personal area network technology aimed at enhancing location services for mobile devices. The small bluetooth tag devices placed at strategic locations transmit universally unique identifiers (UUIDs) and, Major and Minor fields as their identity. These details are picked up by bluetooth-enabled smartphones and devices. The location information of these devices are sent to the corresponding back-end server. Relevant advertisements and other important information are then pushed to the devices using this location-specific information.

The BLE feature also provides BLE beacon management support and specifies its behavior when used within the Cisco WLAN system. Using the Cisco CleanAir, an access point can identify an iBeacon signal and decode the payload content. The extracted tag device details are used for better management of the device.

By treating a tag device as an interferer and using the existing system capabilities, such as interference location, the tag device can be located on a map display in a wireless LAN deployment and its movement monitored. Besides this, information on missing tags can also be obtained. This feature can determine rogue and malicious tags using the unique identifier associated with each tag (or family of tags) against a predetermined whitelist from a customer. Using the management function, alerts can be displayed or emailed based on rogue tags, missing tags, or moved tags.

### Limitations of BLE Feature

- The wireless infrastructure must support Cisco CleanAir.
- Supports a maximum of only 250 unique BLE beacons (cluster entries) and 1000 device entries.
- The BLE feature on the Cisco Aironet 3700 Series Access Points with Halo module gets deactivated when NTP is configured (This behavior is also observed when Cisco CMX is not present.) So, the legacy BLE does not work when Cisco CMX is present or not configured for Hyperlocation.

### Areas of Use

Since the BLE feature provides granular location details of devices (smart phones or bluetooth-enabled devices) that helps push context-sensitive advertising and other information to users. Possible areas of application include retail stores, museums, zoo, healthcare, fitness, security, advertising, and so on.

# Enabling Bluetooth Low Energy Beacon

Bluetooth low energy (BLE) detection is enabled by default. Use the procedure given below to enable BLE when it is disabled.

## Before you begin

- The wireless infrastructure must support Cisco CleanAir.
- Cisco CleanAir configuration and show commands are available only in Mobility Controller (MC) mode.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Controller# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>[no] ap dot11 24ghz cleanair device [ble-beacon]</b> <b>Example:</b> Controller(config)# ap dot11 24ghz cleanair device ble-beacon	Enables the BLE feature on the 802.11b network. Use the <b>no</b> form of the command to disable BLE feature on the 802.11b network.
<b>Step 3</b>	<b>exit</b> <b>Example:</b> Controller(config)# exit	Returns to privileged EXEC mode.
<b>Step 4</b>	<b>show ap dot11 24ghz cleanair config</b> <b>Example:</b> Controller# show ap dot11 24ghz cleanair config  Interference Device Settings: Interference Device Reporting..... : Enabled Bluetooth Link..... : Enabled  Microwave Oven..... : Enabled  BLE Beacon..... : Enabled	(Optional) Displays the BLE beacon configuration.



	Command or Action	Purpose
<b>Step 5</b>	<p><b>show ap dot11 24ghz cleanair device type ble-beacon</b></p> <p><b>Example:</b></p> <pre> Controller# show ap dot11 24ghz cleanair device type ble-beacon  DC      = Duty Cycle (%) ISI     = Interference Severity Index (1-Low Interference, 100-High Interference) RSSI    = Received Signal Strength Index (dBm) DevID   = Device ID  No      ClusterID          DevID  Type         AP Name              ISI   RSSI DC      Channel  1      2c:92:80:00:00:22  0xa001 BLE Beacon         5508_3_AP3600_f839    --   -74 0      unknown </pre>	(Optional) Displays the BLE beacon device-type information.





## PART **IV**

# Interface and Hardware Component

- [Configuring Interface Characteristics, on page 87](#)
- [Configuring Auto-MDIX, on page 123](#)
- [Configuring Ethernet Management Port, on page 127](#)
- [Configuring LLDP, LLDP-MED, and Wired Location Service, on page 133](#)
- [Configuring System MTU, on page 151](#)
- [Configuring Internal Power Supplies, on page 161](#)
- [Configuring PoE, on page 165](#)
- [Configuring the Cisco eXpandable Power System \(XPS\) 2200, on page 177](#)
- [Configuring EEE, on page 187](#)





## CHAPTER 5

# Configuring Interface Characteristics

- [Information About Configuring Interface Characteristics, on page 87](#)
- [How to Configure Interface Characteristics, on page 99](#)
- [Monitoring Interface Characteristics, on page 115](#)
- [Configuration Examples for Interface Characteristics, on page 117](#)
- [Additional References for the Interface Characteristics Feature, on page 120](#)
- [Feature History and Information for Configuring Interface Characteristics, on page 121](#)

## Information About Configuring Interface Characteristics

### Interface Types

This section describes the different types of interfaces supported by the device. The rest of the chapter describes configuration procedures for physical interface characteristics.



**Note** The stack ports on the rear of the stacking-capable devices are not Ethernet ports and cannot be configured.

### Port-Based VLANs

A VLAN is a switched network that is logically segmented by function, team, or application, without regard to the physical location of the users. Packets received on a port are forwarded only to ports that belong to the same VLAN as the receiving port. Network devices in different VLANs cannot communicate with one another without a Layer 3 device to route traffic between the VLANs.

VLAN partitions provide hard firewalls for traffic in the VLAN, and each VLAN has its own MAC address table. A VLAN comes into existence when a local port is configured to be associated with the VLAN, when the VLAN Trunking Protocol (VTP) learns of its existence from a neighbor on a trunk, or when a user creates a VLAN. VLANs can be formed with ports across the stack.

To configure VLANs, use the **vlan *vlan-id*** global configuration command to enter VLAN configuration mode. The VLAN configurations for normal-range VLANs (VLAN IDs 1 to 1005) are saved in the VLAN database. If VTP is version 1 or 2, to configure extended-range VLANs (VLAN IDs 1006 to 4094), you must first set VTP mode to transparent. Extended-range VLANs created in transparent mode are not added to the VLAN

database but are saved in the device running configuration. With VTP version 3, you can create extended-range VLANs in client or server mode. These VLANs are saved in the VLAN database.

In a switch stack, the VLAN database is downloaded to all switches in a stack, and all switches in the stack build the same VLAN database. The running configuration and the saved configuration are the same for all switches in a stack.

Add ports to a VLAN by using the **switchport** interface configuration commands:

- Identify the interface.
- For a trunk port, set trunk characteristics, and, if desired, define the VLANs to which it can belong.
- For an access port, set and define the VLAN to which it belongs.

## Switch Ports

Switch ports are Layer 2-only interfaces associated with a physical port. Switch ports belong to one or more VLANs. A switch port can be an access port or a trunk port. You can configure a port as an access port or trunk port or let the Dynamic Trunking Protocol (DTP) operate on a per-port basis to set the switchport mode by negotiating with the port on the other end of the link. switch ports are used for managing the physical interface and associated Layer 2 protocols and do not handle routing or bridging.

Configure switch ports by using the **switchport** interface configuration commands.

### Access Ports

An access port belongs to and carries the traffic of only one VLAN (unless it is configured as a voice VLAN port). Traffic is received and sent in native formats with no VLAN tagging. Traffic arriving on an access port is assumed to belong to the VLAN assigned to the port. If an access port receives a tagged packet (Inter-Switch Link [ISL] or IEEE 802.1Q tagged), the packet is dropped, and the source address is not learned.

The types of access ports supported are:

- Static access ports are manually assigned to a VLAN (or through a RADIUS server for use with IEEE 802.1x).

You can also configure an access port with an attached Cisco IP Phone to use one VLAN for voice traffic and another VLAN for data traffic from a device attached to the phone.

### Trunk Ports

A trunk port carries the traffic of multiple VLANs and by default is a member of all VLANs in the VLAN database.

Although by default, a trunk port is a member of every VLAN known to the VTP, you can limit VLAN membership by configuring an allowed list of VLANs for each trunk port. The list of allowed VLANs does not affect any other port but the associated trunk port. By default, all possible VLANs (VLAN ID 1 to 4094) are in the allowed list. A trunk port can become a member of a VLAN only if VTP knows of the VLAN and if the VLAN is in the enabled state. If VTP learns of a new, enabled VLAN and the VLAN is in the allowed list for a trunk port, the trunk port automatically becomes a member of that VLAN and traffic is forwarded to and from the trunk port for that VLAN. If VTP learns of a new, enabled VLAN that is not in the allowed list for a trunk port, the port does not become a member of the VLAN, and no traffic for the VLAN is forwarded to or from the port.

## Tunnel Ports

Tunnel ports are used in IEEE 802.1Q tunneling to segregate the traffic of customers in a service-provider network from other customers who are using the same VLAN number. You configure an asymmetric link from a tunnel port on a service-provider edge switch to an IEEE 802.1Q trunk port on the customer switch. Packets entering the tunnel port on the edge switch, already IEEE 802.1Q-tagged with the customer VLANs, are encapsulated with another layer of an IEEE 802.1Q tag (called the metro tag), containing a VLAN ID unique in the service-provider network, for each customer. The double-tagged packets go through the service-provider network keeping the original customer VLANs separate from those of other customers. At the outbound interface, also a tunnel port, the metro tag is removed, and the original VLAN numbers from the customer network are retrieved.

Tunnel ports cannot be trunk ports or access ports and must belong to a VLAN unique to each customer.

## Routed Ports

A routed port is a physical port that acts like a port on a router; it does not have to be connected to a router. A routed port is not associated with a particular VLAN, as is an access port. A routed port behaves like a regular router interface, except that it does not support VLAN subinterfaces. Routed ports can be configured with a Layer 3 routing protocol. A routed port is a Layer 3 interface only and does not support Layer 2 protocols, such as DTP and STP.

Configure routed ports by putting the interface into Layer 3 mode with the **no switchport** interface configuration command. Then assign an IP address to the port, enable routing, and assign routing protocol characteristics by using the **ip routing** and **router protocol** global configuration commands.



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**Note** Entering a **no switchport** interface configuration command shuts down the interface and then re-enables it, which might generate messages on the device to which the interface is connected. When you put an interface that is in Layer 2 mode into Layer 3 mode, the previous configuration information related to the affected interface might be lost.

---

The number of routed ports that you can configure is not limited by software. However, the interrelationship between this number and the number of other features being configured might impact CPU performance because of hardware limitations.



---

**Note** The IP Base image supports static routing and the Routing Information Protocol (RIP). For full Layer 3 routing or for fallback bridging, you must enable the IP Services image on the standalone device, or the active device

## Switch Virtual Interfaces

A switch virtual interface (SVI) represents a VLAN of switch ports as one interface to the routing or bridging function in the system. You can associate only one SVI with a VLAN. You configure an SVI for a VLAN only to route between VLANs or to provide IP host connectivity to the device. By default, an SVI is created for the default VLAN (VLAN 1) to permit remote device administration. Additional SVIs must be explicitly configured.



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**Note** You cannot delete interface VLAN 1.

SVIs provide IP host connectivity only to the system. SVIs are created the first time that you enter the **vlan** interface configuration command for a VLAN interface. The VLAN corresponds to the VLAN tag associated with data frames on an ISL or IEEE 802.1Q encapsulated trunk or the VLAN ID configured for an access port. Configure a VLAN interface for each VLAN for which you want to route traffic, and assign it an IP address.

You can also use the interface range command to configure existing VLAN SVIs within the range. The commands entered under the interface range command are applied to all existing VLAN SVIs within the range. You can enter the command **interface range create vlan x - y** to create all VLANs in the specified range that do not already exist. When the VLAN interface is created, **interface range vlan id** can be used to configure the VLAN interface.

Although the switch stack or device supports a total of 1005 VLANs and SVIs, the interrelationship between the number of SVIs and routed ports and the number of other features being configured might impact CPU performance because of hardware limitations.

When you create an SVI, it does not become active until it is associated with a physical port.

## SVI Autostate Exclude

The line state of an SVI with multiple ports on a VLAN is in the *up* state when it meets these conditions:

- The VLAN exists and is active in the VLAN database on the device
- The VLAN interface exists and is not administratively down.
- At least one Layer 2 (access or trunk) port exists, has a link in the *up* state on this VLAN, and is in the spanning-tree forwarding state on the VLAN.



### Note

The protocol link state for VLAN interfaces come up when the first switchport belonging to the corresponding VLAN link comes up and is in STP forwarding state.

The default action, when a VLAN has multiple ports, is that the SVI goes down when all ports in the VLAN go down. You can use the SVI autostate exclude feature to configure a port so that it is not included in the SVI line-state up-or-down calculation. For example, if the only active port on the VLAN is a monitoring port, you might configure autostate exclude on that port so that the VLAN goes down when all other ports go down. When enabled on a port, **autostate exclude** applies to all VLANs that are enabled on that port.

The VLAN interface is brought up when one Layer 2 port in the VLAN has had time to converge (transition from STP listening-learning state to forwarding state). This prevents features such as routing protocols from using the VLAN interface as if it were fully operational and minimizes other problems, such as routing black holes.

## EtherChannel Port Groups

EtherChannel port groups treat multiple switch ports as one switch port. These port groups act as a single logical port for high-bandwidth connections between devices or between devices and servers. An EtherChannel balances the traffic load across the links in the channel. If a link within the EtherChannel fails, traffic previously carried over the failed link changes to the remaining links. You can group multiple trunk ports into one logical trunk port, group multiple access ports into one logical access port, group multiple tunnel ports into one logical tunnel port, or group multiple routed ports into one logical routed port. Most protocols operate over either single ports or aggregated switch ports and do not recognize the physical ports within the port group. Exceptions



are the DTP, the Cisco Discovery Protocol (CDP), and the Port Aggregation Protocol (PAgP), which operate only on physical ports.

When you configure an EtherChannel, you create a port-channel logical interface and assign an interface to the EtherChannel. For Layer 3 interfaces, you manually create the logical interface by using the **interface port-channel** global configuration command. Then you manually assign an interface to the EtherChannel by using the **channel-group** interface configuration command. For Layer 2 interfaces, use the **channel-group** interface configuration command to dynamically create the port-channel logical interface. This command binds the physical and logical ports together.

## 10-Gigabit Ethernet Interfaces

A 10-Gigabit Ethernet interface operates only in full-duplex mode. The interface can be configured as a switched or routed port.

The device has a network module slot into which you can insert a 10-Gigabit Ethernet network module, a 1-Gigabit Ethernet network module, or a blank module.

For more information about the Cisco TwinGig Converter Module, see the device hardware installation guide and your transceiver module documentation.

## Multigigabit Ethernet

The MultiGigabit Ethernet (mGig) feature allows you to configure speeds beyond 1Gbps on Cisco 802.11ac Wave2 Access Points (APs) Ethernet port. This technology supports speeds of 100 Mbps, 1 Gbps, 2.5 Gbps, and 5 Gbps with automatic bandwidth negotiation over traditional CAT5e cables and higher cable variants. mGig is supported with Cisco 3800 Series access points and on the Cisco Catalyst switches mentioned below.

The following Cisco switches support the mGig feature:

- WS-C3850-12X48U
- WS-C3850-24XU

Multigigabit Ethernet supports multi-rate speeds where the ports exchange auto-negotiation pages to establish a link at the highest speed that is supported by both ends of the channel. In a high-noise environment, when port speed downshifting is enabled on an interface, the line rate automatically downgrades to a lower speed when a higher speed link cannot be established or when an established link quality has degraded to a level where the PHY needs to reestablish the link. The following downshift speed values are recommended:

- 10Gbs (downshift to 5Gbs)
- 5Gbs (downshift to 2.5Gbs)
- 2.5Gbs (downshift to 1Gbs)
- 1Gbs (downshift to 100Mbs)

## Power over Ethernet Ports

A PoE-capable switch port automatically supplies power to one of these connected devices if the device senses that there is no power on the circuit:

- a Cisco pre-standard powered device (such as a Cisco IP Phone or a Cisco Aironet Access Point)
- an IEEE 802.3af-compliant powered device

A powered device can receive redundant power when it is connected to a PoE switch port and to an AC power source. The device does not receive redundant power when it is only connected to the PoE port.

## Using the Switch USB Ports

The device has two USB ports on the front panel — a USB mini-Type B console port and a USB Type A port.

### USB Mini-Type B Console Port

The device has the following console ports:

- USB mini-Type B console connection
- RJ-45 console port

Console output appears on devices connected to both ports, but console input is active on only one port at a time. By default, the USB connector takes precedence over the RJ-45 connector.



**Note** Windows PCs require a driver for the USB port. See the hardware installation guide for driver installation instructions.

Use the supplied USB Type A-to-USB mini-Type B cable to connect a PC or other device to the device. The connected device must include a terminal emulation application. When the device detects a valid USB connection to a powered-on device that supports host functionality (such as a PC), input from the RJ-45 console is immediately disabled, and input from the USB console is enabled. Removing the USB connection immediately reenables input from the RJ-45 console connection. An LED on the device shows which console connection is in use.

### Console Port Change Logs

At software startup, a log shows whether the USB or the RJ-45 console is active. Each device in a stack issues this log. Every device always first displays the RJ-45 media type.

In the sample output, Device 1 has a connected USB console cable. Because the bootloader did not change to the USB console, the first log from Device 1 shows the RJ-45 console. A short time later, the console changes and the USB console log appears. Device 2 and Device 3 have connected RJ-45 console cables.

```
switch-stack-1
*Mar 1 00:01:00.171: %USB_CONSOLE-6-MEDIA_RJ45: Console media-type is RJ45.
*Mar 1 00:01:00.431: %USB_CONSOLE-6-MEDIA_USB: Console media-type is USB.
```

```
switch-stack-2
*Mar 1 00:01:09.835: %USB_CONSOLE-6-MEDIA_RJ45: Console media-type is RJ45.
```

```
switch-stack-3
*Mar 1 00:01:10.523: %USB_CONSOLE-6-MEDIA_RJ45: Console media-type is RJ45.
```

When the USB cable is removed or the PC de-activates the USB connection, the hardware automatically changes to the RJ-45 console interface:

```
switch-stack-1
Mar 1 00:20:48.635: %USB_CONSOLE-6-MEDIA_RJ45: Console media-type is RJ45.
```

You can configure the console type to always be RJ-45, and you can configure an inactivity timeout for the USB connector.

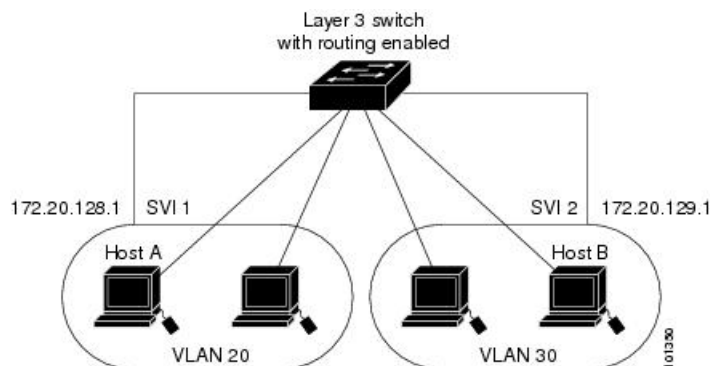
## USB Type A Port

The USB Type A port provides access to external USB flash devices, also known as thumb drives or USB keys. The port supports Cisco USB flash drives with capacities from 128 MB to 8 GB (USB devices with port densities of 128 MB, 256 MB, 1 GB, 4 GB, 8 GB are supported). You can use standard Cisco IOS command-line interface (CLI) commands to read, write, erase, and copy to or from the flash device. You can also configure the device to boot from the USB flash drive.

## Interface Connections

Devices within a single VLAN can communicate directly through any switch. Ports in different VLANs cannot exchange data without going through a routing device. With a standard Layer 2 device, ports in different VLANs have to exchange information through a router. By using the device with routing enabled, when you configure both VLAN 20 and VLAN 30 with an SVI to which an IP address is assigned, packets can be sent from Host A to Host B directly through the device with no need for an external router.

**Figure 5: Connecting VLANs with the Switch**



**Note** Devices running the LAN Base image support configuring only 16 static routes on SVIs.

When the IP Services image is running on the device or the active device, the device uses two methods to forward traffic between interfaces: routing and fallback bridging. If the IP Base image is on the device or the active device, only basic routing (static routing and RIP) is supported. Whenever possible, to maintain high performance, forwarding is done by the device hardware. However, only IPv4 packets with Ethernet II encapsulation are routed in hardware. Non-IP traffic and traffic with other encapsulation methods are fallback-bridged by hardware.

- The routing function can be enabled on all SVIs and routed ports. The device routes only IP traffic. When IP routing protocol parameters and address configuration are added to an SVI or routed port, any IP traffic received from these ports is routed.

- Fallback bridging forwards traffic that the device does not route or traffic belonging to a nonroutable protocol, such as DECnet. Fallback bridging connects multiple VLANs into one bridge domain by bridging between two or more SVIs or routed ports. When configuring fallback bridging, you assign SVIs or routed ports to bridge groups with each SVI or routed port assigned to only one bridge group. All interfaces in the same group belong to the same bridge domain.

## Interface Configuration Mode

The device supports these interface types:

- Physical ports—device ports and routed ports
- VLANs—switch virtual interfaces
- Port channels—EtherChannel interfaces

You can also configure a range of interfaces.

To configure a physical interface (port), specify the interface type, stack member number (only stacking-capable switches), module number, and device port number, and enter interface configuration mode.

- Type—Gigabit Ethernet (gigabitethernet or gi) for 10/100/1000 Mb/s Ethernet ports, 10-Gigabit Ethernet (tengigabitethernet or te) for 10,000 Mb/s, or small form-factor pluggable (SFP) module Gigabit Ethernet interfaces (gigabitethernet or gi).
- Stack member number—The number that identifies the device within the stack. The device number range is 1 to 9 and is assigned the first time the device initializes. The default device number, before it is integrated into a device stack, is 1. When a device has been assigned a stack member number, it keeps that number until another is assigned to it.

You can use the switch port LEDs in Stack mode to identify the stack member number of a device.

- Module number—The module or slot number on the device: switch (downlink) ports are 0, and uplink ports are 1.
- Port number—The interface number on the device. The 10/100/1000 port numbers always begin at 1, starting with the far left port when facing the front of the device, for example, gigabitethernet1/0/1 or gigabitethernet1/0/8.

On a device with SFP uplink ports, the module number is 1 and the port numbers restart. For example, if the device has 24 10/100/1000 ports, the SFP module ports are gigabitethernet1/1/1 through gigabitethernet1/1/4 or tengigabitethernet1/1/1 through tengigabitethernet1/1/4.

You can identify physical interfaces by physically checking the interface location on the device. You can also use the **show** privileged EXEC commands to display information about a specific interface or all the interfaces on the switch. The remainder of this chapter primarily provides physical interface configuration procedures.

These are examples of how to identify interfaces on a stacking-capable device:

- To configure 10/100/1000 port 4 on a standalone device, enter this command:

```
Device(config)# interface gigabitethernet1/0/4
```

- To configure 10-Gigabit Ethernet port 1 on a standalone device, enter this command:

```
Device (config) # interface tengigabitethernet1/0/1
```

- To configure 10-Gigabit Ethernet port on stack member 3, enter this command:

```
Device (config) # interface tengigabitethernet3/0/1
```

- To configure the first SFP module (uplink) port on a standalone device, enter this command:

```
Device (config) # interface gigabitethernet1/1/1
```

## Default Ethernet Interface Configuration

To configure Layer 2 parameters, if the interface is in Layer 3 mode, you must enter the **switchport** interface configuration command without any parameters to put the interface into Layer 2 mode. This shuts down the interface and then re-enables it, which might generate messages on the device to which the interface is connected. When you put an interface that is in Layer 3 mode into Layer 2 mode, the previous configuration information related to the affected interface might be lost, and the interface is returned to its default configuration.

This table shows the Ethernet interface default configuration, including some features that apply only to Layer 2 interfaces.

**Table 4: Default Layer 2 Ethernet Interface Configuration**

Feature	Default Setting
Operating mode	Layer 2 or switching mode ( <b>switchport</b> command).
Allowed VLAN range	VLANs 1– 4094.
Default VLAN (for access ports)	VLAN 1 (Layer 2 interfaces only).
Native VLAN (for IEEE 802.1Q trunks)	VLAN 1 (Layer 2 interfaces only).
VLAN trunking	Switchport mode dynamic auto (supports DTP) (Layer 2 interfaces only).
Port enable state	All ports are enabled.
Port description	None defined.
Speed	Autonegotiate. (Not supported on the 10-Gigabit interfaces.)
Duplex mode	Autonegotiate. (Not supported on the 10-Gigabit interfaces.)
Flow control	Flow control is set to <b>receive: off</b> . It is always off for sent packets.
EtherChannel (PAgP)	Disabled on all Ethernet ports.

Feature	Default Setting
Port blocking (unknown multicast and unknown unicast traffic)	Disabled (not blocked) (Layer 2 interfaces only).
Broadcast, multicast, and unicast storm control	Disabled.
Protected port	Disabled (Layer 2 interfaces only).
Port security	Disabled (Layer 2 interfaces only).
Port Fast	Disabled.
Auto-MDIX	Enabled.  <b>Note</b> The switch might not support a pre-standard powered device—such as Cisco IP phones and access points that do not fully support IEEE 802.3af—if that powered device is connected to the switch through a crossover cable. This is regardless of whether auto-MIDX is enabled on the switch port.
Power over Ethernet (PoE)	Enabled (auto).

## Interface Speed and Duplex Mode

Ethernet interfaces on the switch operate at 10, 100, 1000, or 10,000 Mb/s and in either full- or half-duplex mode. In full-duplex mode, two stations can send and receive traffic at the same time. Normally, 10-Mb/s ports operate in half-duplex mode, which means that stations can either receive or send traffic.

Switch modules include Gigabit Ethernet (10/100/1000-Mb/s) ports, 10-Gigabit Ethernet ports, and small form-factor pluggable (SFP) module slots supporting SFP modules.

## Speed and Duplex Configuration Guidelines

When configuring an interface speed and duplex mode, note these guidelines:

- The 10-Gigabit Ethernet ports do not support the speed and duplex features. These ports operate only at 10,000 Mb/s and in full-duplex mode.
- Do not disable Auto-Negotiation on PoE switches.
- Gigabit Ethernet (10/100/1000-Mb/s) ports support all speed options and all duplex options (auto, half, and full). However, Gigabit Ethernet ports operating at 1000 Mb/s do not support half-duplex mode.
- For SFP module ports, the speed and duplex CLI options change depending on the SFP module type:
  - The 1000BASE-*x* (where *x* is -BX, -CWDM, -LX, -SX, and -ZX) SFP module ports support the **nonegotiate** keyword in the **speed** interface configuration command. Duplex options are not supported.
  - The 1000BASE-T SFP module ports support the same speed and duplex options as the 10/100/1000-Mb/s ports.

- If both ends of the line support autonegotiation, we highly recommend the default setting of **auto** negotiation.
- If one interface supports autonegotiation and the other end does not, configure duplex and speed on both interfaces; do not use the **auto** setting on the supported side.
- When STP is enabled and a port is reconfigured, the device can take up to 30 seconds to check for loops. The port LED is amber while STP reconfigures.
- As best practice, we suggest configuring the speed and duplex options on a link to auto or to fixed on both the ends. If one side of the link is configured to auto and the other side is configured to fixed, the link will not be up and this is expected.

**Caution**

Changing the interface speed and duplex mode configuration might shut down and re-enable the interface during the reconfiguration.

## IEEE 802.3x Flow Control

Flow control enables connected Ethernet ports to control traffic rates during congestion by allowing congested nodes to pause link operation at the other end. If one port experiences congestion and cannot receive any more traffic, it notifies the other port by sending a pause frame to stop sending until the condition clears. Upon receipt of a pause frame, the sending device stops sending any data packets, which prevents any loss of data packets during the congestion period.

**Note**

The switch ports can receive, but not send, pause frames.

Use the **flowcontrol** interface configuration command to set the interface's ability to **receive** pause frames to **on**, **off**, or **desired**. Prior to Cisco IOS XE Denali 16.3.8 release, the default state is **off**. Starting Cisco IOS XE Denali 16.3.8 release, the default state is **on**.

When set to **desired**, an interface can operate with an attached device that is required to send flow-control packets or with an attached device that is not required to but can send flow-control packets.

These rules apply to flow control settings on the device:

- **receive on (or desired)**: The port cannot send pause frames but can operate with an attached device that is required to or can send pause frames; the port can receive pause frames.
- **receive off**: Flow control does not operate in either direction. In case of congestion, no indication is given to the link partner, and no pause frames are sent or received by either device.

## Layer 3 Interfaces

The device supports these types of Layer 3 interfaces:

- SVIs: You should configure SVIs for any VLANs for which you want to route traffic. SVIs are created when you enter a VLAN ID following the **interface vlan** global configuration command. To delete an SVI, use the **no interface vlan** global configuration command. You cannot delete interface VLAN 1.




---

**Note** When you create an SVI, it does not become active until it is associated with a physical port.

---

When configuring SVIs, you can also configure SVI autostate exclude on a port in the SVI to exclude that port from being included in determining SVI line-state status.

- Routed ports: Routed ports are physical ports configured to be in Layer 3 mode by using the **no switchport** interface configuration command.
- Layer 3 EtherChannel ports: EtherChannel interfaces made up of routed ports.

A Layer 3 device can have an IP address assigned to each routed port and SVI.

There is no defined limit to the number of SVIs and routed ports that can be configured in a device or in a device stack. However, the interrelationship between the number of SVIs and routed ports and the number of other features being configured might have an impact on CPU usage because of hardware limitations. If the device is using its maximum hardware resources, attempts to create a routed port or SVI have these results:

- If you try to create a new routed port, the device generates a message that there are not enough resources to convert the interface to a routed port, and the interface remains as a switchport.
- If you try to create an extended-range VLAN, an error message is generated, and the extended-range VLAN is rejected.
- If the device is notified by VLAN Trunking Protocol (VTP) of a new VLAN, it sends a message that there are not enough hardware resources available and shuts down the VLAN. The output of the **show vlan** user EXEC command shows the VLAN in a suspended state.
- If the device attempts to boot up with a configuration that has more VLANs and routed ports than hardware can support, the VLANs are created, but the routed ports are shut down, and the device sends a message that this was due to insufficient hardware resources.




---

**Note** All Layer 3 interfaces require an IP address to route traffic. This procedure shows how to configure an interface as a Layer 3 interface and how to assign an IP address to an interface:

If the physical port is in Layer 2 mode (the default), you must enter the **no switchport** interface configuration command to put the interface into Layer 3 mode. Entering a **no switchport** command disables and then re-enables the interface, which might generate messages on the device to which the interface is connected. Furthermore, when you put an interface that is in Layer 2 mode into Layer 3 mode, the previous configuration information related to the affected interface might be lost, and the interface is returned to its default configuration

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## Digital Optical Monitoring

The switch supports Digital Optical Monitoring (DOM) as per the standard SFF-8724 Multi-Source Agreement (MSA). It enables you to monitor optical input and output power, temperature, and voltage. These parameters are monitored against threshold values and you can display threshold violations for a transceiver installed on a specific interface.

The feature is supported on all transceivers that support DOM and is disabled by default.

### Identifying DOM-Supported Transceivers

Refer to the following publication on cisco.com: [https://www.cisco.com/c/en/us/td/docs/interfaces\\_modules/transceiver\\_modules/compatibility/matrix/DOM\\_matrix.html](https://www.cisco.com/c/en/us/td/docs/interfaces_modules/transceiver_modules/compatibility/matrix/DOM_matrix.html)

OR

Display the list of DOM-supported transceivers on your device. Enter the **show interfaces transceiver supported-list** command in privileged EXEC mode.

## How to Configure Interface Characteristics

### Configuring Interfaces

These general instructions apply to all interface configuration processes.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <b>Example:</b> Device(config)# <b>interface gigabitethernet</b>	Identifies the interface type, the device number (only on stacking-capable switches), and the number of the connector.

	Command or Action	Purpose
	<pre>1/0/1 Device(config-if)#</pre>	<p><b>Note</b> You do not need to add a space between the interface type and the interface number. For example, in the preceding line, you can specify either <b>gigabitethernet 1/0/1</b>, <b>gigabitethernet1/0/1</b>, <b>gi 1/0/1</b>, or <b>gi1/0/1</b>.</p>
<b>Step 4</b>	Follow each <b>interface</b> command with the interface configuration commands that the interface requires.	Defines the protocols and applications that will run on the interface. The commands are collected and applied to the interface when you enter another interface command or enter <b>end</b> to return to privileged EXEC mode.
<b>Step 5</b>	<b>interface range</b> or <b>interface range macro</b>	<p>(Optional) Configures a range of interfaces.</p> <p><b>Note</b> Interfaces configured in a range must be the same type and must be configured with the same feature options.</p>
<b>Step 6</b>	<b>show interfaces</b>	Displays a list of all interfaces on or configured for the switch. A report is provided for each interface that the device supports or for the specified interface.

## Adding a Description for an Interface

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<pre>enable</pre> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<pre>configure terminal</pre> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<pre>interface interface-id</pre> <p><b>Example:</b></p> <pre>Device(config)# interface gigabitethernet</pre>	Specifies the interface for which you are adding a description, and enter interface configuration mode.

	Command or Action	Purpose
	<code>1/0/2</code>	
<b>Step 4</b>	<b>description</b> <i>string</i> <b>Example:</b> <pre>Device(config-if)# description Connects to Marketing</pre>	Adds a description (up to 240 characters) for an interface.
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show interfaces</b> <i>interface-id</i> <b>description</b>	Verifies your entry.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring a Range of Interfaces

To configure multiple interfaces with the same configuration parameters, use the **interface range** global configuration command. When you enter the interface-range configuration mode, all command parameters that you enter are attributed to all interfaces within that range until you exit this mode.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<p><b>interface range</b> {<i>port-range</i>   <b>macro</b> <i>macro_name</i>}</p> <p><b>Example:</b></p> <pre>Device(config)# <b>interface range macro</b></pre>	<p>Specifies the range of interfaces (VLANs or physical ports) to be configured, and enter interface-range configuration mode.</p> <ul style="list-style-type: none"> <li>You can use the <b>interface range</b> command to configure up to five port ranges or a previously defined macro.</li> <li>The <b>macro</b> variable is explained in the section on <i>Configuring and Using Interface Range Macros</i>.</li> <li>In a comma-separated <i>port-range</i>, you must enter the interface type for each entry and enter spaces before and after the comma.</li> <li>In a hyphen-separated <i>port-range</i>, you do not need to re-enter the interface type, but you must enter a space before the hyphen.</li> </ul> <p><b>Note</b> Use the normal configuration commands to apply the configuration parameters to all interfaces in the range. Each command is executed as it is entered.</p>
<b>Step 4</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# <b>end</b></pre>	Returns to privileged EXEC mode.
<b>Step 5</b>	<p><b>show interfaces</b> [<i>interface-id</i>]</p> <p><b>Example:</b></p> <pre>Device# <b>show interfaces</b></pre>	Verifies the configuration of the interfaces in the range.
<b>Step 6</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# <b>copy running-config startup-config</b></pre>	(Optional) Saves your entries in the configuration file.

## Configuring and Using Interface Range Macros

You can create an interface range macro to automatically select a range of interfaces for configuration. Before you can use the **macro** keyword in the **interface range macro** global configuration command string, you must use the **define interface-range** global configuration command to define the macro.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>define interface-range</b> <i>macro_name</i> <i>interface-range</i> <b>Example:</b> <pre>Device(config)# define interface-range enet_list gigabitethernet 1/0/1 - 2</pre>	Defines the interface-range macro, and save it in NVRAM. <ul style="list-style-type: none"> <li>• The <i>macro_name</i> is a 32-character maximum character string.</li> <li>• A macro can contain up to five comma-separated interface ranges.</li> <li>• Each <i>interface-range</i> must consist of the same port type.</li> </ul> <p><b>Note</b> Before you can use the <b>macro</b> keyword in the <b>interface range macro</b> global configuration command string, you must use the <b>define interface-range</b> global configuration command to define the macro.</p>
<b>Step 4</b>	<b>interface range macro</b> <i>macro_name</i> <b>Example:</b> <pre>Device(config)# interface range macro enet_list</pre>	Selects the interface range to be configured using the values saved in the interface-range macro called <i>macro_name</i> .  You can now use the normal configuration commands to apply the configuration to all interfaces in the defined macro.
<b>Step 5</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	<code>Device(config)# end</code>	
<b>Step 6</b>	<b>show running-config   include define</b> <b>Example:</b>  <code>Device# show running-config   include define</code>	Shows the defined interface range macro configuration.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b>  <code>Device# copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring Ethernet Interfaces

### Setting the Interface Speed and Duplex Parameters

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  <code>Device&gt; enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  <code>Device# configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  <code>Device(config)# interface gigabitethernet 1/0/3</code>	Specifies the physical interface to be configured, and enter interface configuration mode.
<b>Step 4</b>	<b>speed {10   100   1000   2500   5000   10000   auto [10   100   1000   2500   5000   10000]   nonegotiate}</b>	Enter the appropriate speed parameter for the interface:

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config-if)# speed 10</pre>	<ul style="list-style-type: none"> <li>• Enter <b>10, 100, 1000 2500, 5000, or 10000</b> to set a specific speed for the interface.</li> <li>• Enter <b>auto</b> to enable the interface to autonegotiate speed with the connected device. If you specify a speed and also set the <b>auto</b> keyword, the port autonegotiates only at the specified speeds.</li> <li>• The <b>nonegotiate</b> keyword is available only for SFP module ports. SFP module ports operate only at 1000 Mb/s but can be configured to not negotiate if connected to a device that does not support autonegotiation.</li> </ul>
<b>Step 5</b>	<p><b>duplex {auto   full   half}</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# duplex half</pre>	<p>This command is not available on a 10-Gigabit Ethernet interface.</p> <p>Enter the duplex parameter for the interface.</p> <p>Enable half-duplex mode (for interfaces operating only at 10 or 100 Mb/s). You cannot configure half-duplex mode for interfaces operating at 1000 Mb/s.</p> <p>You can configure the duplex setting when the speed is set to <b>auto</b>.</p>
<b>Step 6</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# end</pre>	<p>Returns to privileged EXEC mode.</p>
<b>Step 7</b>	<p><b>show interfaces <i>interface-id</i></b></p> <p><b>Example:</b></p> <pre>Device# show interfaces gigabitethernet 1/0/3</pre>	<p>Displays the interface speed and duplex mode configuration.</p>
<b>Step 8</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	<p>(Optional) Saves your entries in the configuration file.</p>

## Configuring Multigigabit Ethernet Parameters

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>interface</b> tengigabitethernet <i>interface number</i> <b>Example:</b>  Device(config)# <b>interface</b> <b>tengigabitethernet 1/1/37</b>	Configures the 10 Gigabit Ethernet interface.
<b>Step 2</b>	<b>speed auto</b> <b>Example:</b>  Device(config-if)# <b>speed auto</b>	Sets the speed to auto speed negotiation.
<b>Step 3</b>	<b>downshift</b> <b>Example:</b>  Device(config-if)# <b>downshift</b>	Enables downshift on the specified interface. When downshift is enabled, the port speed gets downshifted or lowered, if the link quality is bad or if the link is continuously down.
<b>Step 4</b>	<b>no downshift</b> <b>Example:</b>  Device(config-if)# <b>no downshift</b>	Disables downshift on the specified interface. By default, downshift is enabled on all the multigigabit ports. Use the <b>no downshift</b> command to disable downshift on an interface.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show interfaces downshift</b> <b>Example:</b>  Device# <b>show interfaces downshift</b>	(Optional) Displays downshift status of all the multigigabit ports.
<b>Step 7</b>	<b>show interfaces <i>interface-number</i> downshift</b> <b>Example:</b>  Device# <b>show interfaces</b> <b>TenGigabitEthernet 1/0/1 downshift</b>	(Optional) Displays downshift status of the specified multigigabit port.
<b>Step 8</b>	<b>show interfaces downshift module <i>module-number</i></b> <b>Example:</b>  Device# <b>show interface downshift module</b> <b>1</b>	(Optional) Displays downshift status of the specified module.



	Command or Action	Purpose
<b>Step 9</b>	<b>show ap name <i>ap-name</i> ethernet statistics</b> <b>Example:</b>  Device# <b>show ap name testAP ethernet statistics</b>	(Optional) Displays the Ethernet statistics of a specific AP.

## Configuring IEEE 802.3x Flow Control

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device(config)# <b>interface gigabitethernet 1/0/1</b>	Specifies the physical interface to be configured, and enter interface configuration mode.
<b>Step 3</b>	<b>flowcontrol {receive} {on   off   desired}</b> <b>Example:</b>  Device(config-if)# <b>flowcontrol receive on</b>	Configures the flow control mode for the port.
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show interfaces <i>interface-id</i></b> <b>Example:</b>  Device# <b>show interfaces gigabitethernet 1/0/1</b>	Verifies the interface flow control settings.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Device# <code>copy running-config startup-config</code>	

## Configuring Layer 3 Interfaces

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> { <i>gigabitethernet interface-id</i> }   { <i>vlan vlan-id</i> }   { <i>port-channel port-channel-number</i> } <b>Example:</b> Device(config)# <code>interface gigabitethernet1/0/2</code>	Specifies the interface to be configured as a Layer 3 interface, and enter interface configuration mode.
<b>Step 4</b>	<b>no switchport</b> <b>Example:</b> Device(config-if)# <code>no switchport</code>	For physical ports only, enters Layer 3 mode.
<b>Step 5</b>	<b>ip address</b> <i>ip_address subnet_mask</i> <b>Example:</b> Device(config-if)# <code>ip address 192.20.135.21 255.255.255.0</code>	Configures the IP address and IP subnet.
<b>Step 6</b>	<b>no shutdown</b> <b>Example:</b> Device(config-if)# <code>no shutdown</code>	Enables the interface.

	Command or Action	Purpose
<b>Step 7</b>	<b>end</b> <b>Example:</b>  Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show interfaces</b> [ <i>interface-id</i> ]	Verifies the configuration.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring Logical Layer 3 GRE Tunnel Interfaces

### Before you begin

Generic Routing Encapsulation (GRE) is a tunneling protocol used to encapsulate network layer protocols inside virtual point-to-point links. A GRE tunnel only provides encapsulation and not encryption.



#### Attention

Beginning in Cisco IOS XE Release 3.7.2E, GRE tunnels are supported on the hardware on Cisco Catalyst switches. When GRE is configured without tunnel options, packets are hardware-switched. When GRE is configured with tunnel options (such as key, checksum, etc.), packets are switched in the software. A maximum of 10 GRE tunnels are supported.



#### Note

Other features like Access Control Lists (ACL) and Quality of Service (QoS) are not supported for the GRE tunnels.

To configure a GRE tunnel, perform this task:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>interface tunnel</b> <i>number</i> <b>Example:</b>  Device(config)# <b>interface tunnel</b> 2	Enables tunneling on the interface.
<b>Step 2</b>	<b>ip address</b> <i>ip_address</i> <i>subnet_mask</i> <b>Example:</b>	Configures the IP address and IP subnet.

	Command or Action	Purpose
	Device (config) # <b>ip address</b> 100.1.1.1 255.255.255.0	
<b>Step 3</b>	<b>tunnel source</b> { <i>ip_address</i>   <i>type_number</i> } <b>Example:</b> Device (config) # <b>tunnel source</b> 10.10.10.1	Configures the tunnel source.
<b>Step 4</b>	<b>tunnel destination</b> { <i>host_name</i>   <i>ip_address</i> } <b>Example:</b> Device (config) # <b>tunnel destination</b> 10.10.10.2	Configures the tunnel destination.
<b>Step 5</b>	<b>tunnel mode gre ip</b> <b>Example:</b> Device (config) # <b>tunnel mode gre ip</b>	Configures the tunnel mode.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Exist configuration mode.

## Configuring SVI Autostate Exclude

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> Device (config) # <b>interface</b> <b>gigabitethernet1/0/2</b>	Specifies a Layer 2 interface (physical port or port channel), and enter interface configuration mode.
<b>Step 4</b>	<b>switchport autostate exclude</b> <b>Example:</b>	Excludes the access or trunk port when defining the status of an SVI line state (up or down)

	Command or Action	Purpose
	Device(config-if)# <b>switchport autostate exclude</b>	
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running config interface <i>interface-id</i></b>	(Optional) Shows the running configuration. Verifies the configuration.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Shutting Down and Restarting the Interface

Shutting down an interface disables all functions on the specified interface and marks the interface as unavailable on all monitoring command displays. This information is communicated to other network servers through all dynamic routing protocols. The interface is not mentioned in any routing updates.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"><li>• Enter your password if prompted.</li></ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface {vlan <i>vlan-id</i>}   {gigabitethernet<i>interface-id</i>}   {port-channel <i>port-channel-number</i>}</b> <b>Example:</b> Device(config)# <b>interface gigabitethernet</b>	Selects the interface to be configured.

	Command or Action	Purpose
	1/0/2	
<b>Step 4</b>	<b>shutdown</b> <b>Example:</b> Device(config-if) # <b>shutdown</b>	Shuts down an interface.
<b>Step 5</b>	<b>no shutdown</b> <b>Example:</b> Device(config-if) # <b>no shutdown</b>	Restarts an interface.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config-if) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.

## Configuring the Console Media Type

Follow these steps to set the console media type to RJ-45. If you configure the console as RJ-45, USB console operation is disabled, and input comes only through the RJ-45 connector.

This configuration applies to all switches in a stack.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>line console 0</b> <b>Example:</b>  Device(config)# <b>line console 0</b>	Configures the console and enters line configuration mode.
<b>Step 4</b>	<b>media-type rj45</b> <b>Example:</b>  Device(config-line)# <b>media-type rj45</b>	Configures the console media type to be only RJ-45 port. If you do not enter this command and both types are connected, the USB port is used by default.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring the USB Inactivity Timeout

The configurable inactivity timeout reactivates the RJ-45 console port if the USB console port is activated but no input activity occurs on it for a specified time period. When the USB console port is deactivated due to a timeout, you can restore its operation by disconnecting and reconnecting the USB cable.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>line console 0</b> <b>Example:</b> Device(config)# <b>line console 0</b>	Configures the console and enters line configuration mode.
<b>Step 4</b>	<b>usb-inactivity-timeout</b> <i>timeout-minutes</i> <b>Example:</b> Device(config-line)# <b>usb-inactivity-timeout 30</b>	Specify an inactivity timeout for the console port. The range is 1 to 240 minutes. The default is to have no timeout configured.
<b>Step 5</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Enabling Digital Optical Monitoring

Complete the following steps to enable transceiver monitoring:



### Note

- In case of combo ports with an SFP and RJ45 provision, when an SFP transceiver is inserted in the slot or port and media type is not configured as SFP, DOM is functional only if global transceiver monitoring is enabled.
- CISCO-ENTITY-SENSOR-MIB traps are sent only once after a threshold violation. However, SYSLOG messages are sent according to the monitoring interval.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.



	Command or Action	Purpose
<b>Step 3</b>	<b>transceiver type all</b> <b>Example:</b> Device(config) # <b>transceiver type</b>	Enters the transceiver type configuration mode.
<b>Step 4</b>	<b>monitoring intervalseconds</b> <b>Example:</b> Device(config-xcvr-type) # <b>monitoring interval 500</b>	Enables monitoring of all optical transceivers. You can specify the interval at which polling of monitoring parameters occurs. The valid range is 300 to 3600 seconds, and the default is 600 seconds. If you specify this interval as 500 seconds, for example, the system polls for DOM data every 500 seconds.

### What to do next

After you have enabled monitoring, you can use these **show** commands to display real-time parameters of the device:

- **show interfaces transceiver**
- **show interfaces transceiver detail**
- **show interfaces *interface-id* transceiver**

## Monitoring Interface Characteristics

### Monitoring Interface Status

Commands entered at the privileged EXEC prompt display information about the interface, including the versions of the software and the hardware, the configuration, and statistics about the interfaces.

*Table 5: Show Commands for Interfaces*

Command	Purpose
<b>show interfaces <i>interface-number</i> downshift module<i>module-number</i></b>	Displays the downshift status details of the specified interfaces and modules.
<b>show interfaces <i>interface-id</i> status [err-disabled]</b>	Displays interface status or a list of interfaces in the error-disabled state.
<b>show interfaces [<i>interface-id</i>] switchport</b>	Displays administrative and operational status of switching (nonrouting) ports. You can use this command to find out if a port is in routing or in switching mode.
<b>show interfaces [<i>interface-id</i>] description</b>	Displays the description configured on an interface or all interfaces and the interface status.

Command	Purpose
<b>show ip interface</b> [ <i>interface-id</i> ]	Displays the usability status of all interfaces configured for IP routing or the specified interface.
<b>show interface</b> [ <i>interface-id</i> ] <b>stats</b>	Displays the input and output packets by the switching path for the interface.
<b>show interfaces</b> <i>interface-id</i>	(Optional) Displays speed and duplex on the interface.
<b>show interfaces transceiver dom-supported-list</b>	(Optional) Displays Digital Optical Monitoring (DOM) status on the connect SFP modules.
<b>show interfaces transceiver properties</b>	(Optional) Displays temperature, voltage, or amount of current on the interface.
<b>show interfaces</b> [ <i>interface-id</i> ] [{ <b>transceiver properties</b>   <b>detail</b> }] <i>module number</i>	Displays physical and operational status about an SFP module.
<b>show running-config interface</b> [ <i>interface-id</i> ]	Displays the running configuration in RAM for the interface.
<b>show version</b>	Displays the hardware configuration, software version, the names and sources of configuration files, and the boot images.
<b>show controllers ethernet-controller</b> <i>interface-id phy</i>	Displays the operational state of the auto-MDIX feature on the interface.

## Clearing and Resetting Interfaces and Counters

Table 6: Clear Commands for Interfaces

Command	Purpose
<b>clear counters</b> [ <i>interface-id</i> ]	Clears interface counters.
<b>clear interface</b> <i>interface-id</i>	Resets the hardware logic on an interface.
<b>clear line</b> [ <i>number</i>   <b>console 0</b>   <b>vty number</b> ]	Resets the hardware logic on an asynchronous serial line.



**Note** The **clear counters** privileged EXEC command does not clear counters retrieved by using Simple Network Management Protocol (SNMP), but only those seen with the **show interface** privileged EXEC command.

# Configuration Examples for Interface Characteristics

## Adding a Description to an Interface: Example

## Displaying Downshift Status of Interfaces: Examples

This example shows how to display the downshift status of all the multi-gigabit ports.

```
Device# show interfaces downshift
```

Port	Enabled	Active	AdminSpeed	OperSpeed
Te2/0/37	yes	no	auto	auto
Te2/0/38	yes	no	auto	10G
Te2/0/39	yes	no	auto	auto
Te2/0/40	yes	no	auto	10G
Te2/0/41	yes	no	auto	auto
Te2/0/42	yes	no	auto	auto
Te2/0/43	yes	yes	auto	5000
Te2/0/44	yes	no	auto	auto
Te2/0/45	yes	yes	auto	2500
Te2/0/46	yes	no	auto	auto
Te2/0/47	yes	no	auto	10G
Te2/0/48	yes	no	auto	auto

This example shows how to display the downshift status of the specified multi-gigabit port.

```
Device# show interfaces te2/0/43 downshift
```

Port	Enabled	Active	AdminSpeed	OperSpeed
Te2/0/43	yes	yes	10G	5000

The fields in command output are explained below:

Port	Displays the interface number
Enabled	Indicates that Downshift is enabled (yes) / disabled (no) on the specified port
Active	Displays whether Downshift has occurred on the interface or not
AdminSpeed	Displays the speed set by the user (or) default interface speed
OperSpeed	Displays current operational speed on the interface

## Configuring a Range of Interfaces: Examples

This example shows how to use the **interface range** global configuration command to set the speed to 100 Mb/s on ports 1 to 4 on switch 1:

```
Device# configure terminal
```

```
Device(config)# interface range gigabitethernet 1/0/1 - 4
Device(config-if-range)# speed 100
```

This example shows how to use a comma to add different interface type strings to the range to enable Gigabit Ethernet ports 1 to 3 and 10-Gigabit Ethernet ports 1 and 2 to receive flow-control pause frames:

```
Device# configure terminal
Device(config)# interface range gigabitethernet1/0/1 - 3 , tengigabitethernet1/1/1 - 2
Device(config-if-range)# flowcontrol receive on
```

If you enter multiple configuration commands while you are in interface-range mode, each command is executed as it is entered. The commands are not batched and executed after you exit interface-range mode. If you exit interface-range configuration mode while the commands are being executed, some commands might not be executed on all interfaces in the range. Wait until the command prompt reappears before exiting interface-range configuration mode.

## Configuring and Using Interface Range Macros: Examples

This example shows how to define an interface-range named *enet\_list* to include ports 1 and 2 on switch 1 and to verify the macro configuration:

```
Device# configure terminal
Device(config)# define interface-range enet_list gigabitethernet 1/1/1 - 2
Device(config)# end
Device# show running-config | include define
define interface-range enet_list gigabitethernet 1/1/1 - 2
```

This example shows how to create a multiple-interface macro named *macro1*:

```
Device# configure terminal
Device(config)# define interface-range macro1 gigabitethernet1/1/1 - 2, gigabitethernet1/1/5
- 7, tengigabitethernet1/1/1 -2
Device(config)# end
```

This example shows how to enter interface-range configuration mode for the interface-range macro *enet\_list*:

```
Device# configure terminal
Device(config)# interface range macro enet_list
Device(config-if-range)#
```

This example shows how to delete the interface-range macro *enet\_list* and to verify that it was deleted.

```
Device# configure terminal
Device(config)# no define interface-range enet_list
Device(config)# end
Device# show run | include define
Device#
```

## Setting Interface Speed and Duplex Mode: Example

This example shows how to set the interface speed to 100 Mb/s and the duplex mode to half on a 10/100/1000 Mb/s port:

```
Device# configure terminal
Device(config)# interface gigabitethernet 1/0/3
Device(config-if)# speed 10
Device(config-if)# duplex half
```

This example shows how to set the interface speed to 100 Mb/s on a 10/100/1000 Mb/s port:

```
Device# configure terminal
Device(config)# interface gigabitethernet 1/0/2
Device(config-if)# speed 100
```

## Configuring Layer 3 Interfaces: Example

```
Device# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Device(config)# interface gigabitethernet1/0/2
Device(config-if)# no switchport
Device(config-if)# ip address 192.20.135.21 255.255.255.0
Device(config-if)# no shutdown
```

## Configuring the Console Media Type: Example

This example disables the USB console media type and enables the RJ-45 console media type.

```
Device# configure terminal
Device(config)# line console 0
Device(config-line)# media-type rj45
```

This example reverses the previous configuration and immediately activates any USB console that is connected.

```
Device# configure terminal
Device(config)# line console 0
Device(config-line)# no media-type rj45
```

## Configuring the USB Inactivity Timeout: Example

This example configures the inactivity timeout to 30 minutes:

```
Device# configure terminal
Device(config)# line console 0
Device(config-line)# usb-inactivity-timeout 30
```

To disable the configuration, use these commands:

```
Device# configure terminal
Device(config)# line console 0
Device(config-line)# no usb-inactivity-timeout
```

If there is no (input) activity on a USB console port for the configured number of minutes, the inactivity timeout setting applies to the RJ-45 port, and a log shows this occurrence:

```
*Mar  1 00:47:25.625: %USB_CONSOLE-6-INACTIVITY_DISABLE: Console media-type USB disabled
due to inactivity, media-type reverted to RJ45.
```

At this point, the only way to reactivate the USB console port is to disconnect and reconnect the cable.

When the USB cable on the switch has been disconnected and reconnected, a log similar to this appears:

```
*Mar  1 00:48:28.640: %USB_CONSOLE-6-MEDIA_USB: Console media-type is USB.
```

## Additional References for the Interface Characteristics Feature

### Related Documents

Related Topic	Document Title
Platform-independent command reference	<i>Interface and Hardware Command Reference, Cisco IOS XE Release 3.2SE (Catalyst 3850 Switches)</i>
Platform-independent configuration information	<i>Interface and Hardware Component Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>

### Standards and RFCs

Standard/RFC	Title
None	--

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for Configuring Interface Characteristics

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.
Cisco IOS XE 3.7.2E	Support for configuring GRE tunnels in the hardware. When GRE is configured without tunnel options, packets are hardware-switched.
Cisco IOS XE Denali 16.3.2	<p>Support for downshift on mGig interfaces was introduced.</p> <p>When port speed downshifting is enabled on an interface, the line rate automatically downgrades to a lower speed if the link quality is bad or if the link is continuously down.</p>
Cisco IOS XE Denali 16.3.6	<p>Support for Digital Optical Monitoring was introduced. It enables you to monitor optical input and output power, temperature, and voltage.</p> <p>The feature is supported on all transceivers that support DOM and is disabled by default.</p>







## CHAPTER 6

# Configuring Auto-MDIX

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- [Prerequisites for Auto-MDIX, on page 123](#)
- [Restrictions for Auto-MDIX, on page 123](#)
- [Information About Configuring Auto-MDIX, on page 124](#)
- [How to Configure Auto-MDIX, on page 124](#)
- [Example for Configuring Auto-MDIX, on page 125](#)
- [Additional References, on page 126](#)
- [Feature History and Information for Auto-MDIX, on page 126](#)

## Prerequisites for Auto-MDIX

To configure Layer 2 parameters, if the interface is in Layer 3 mode, you must enter the **switchport** interface configuration command without any parameters to put the interface into Layer 2 mode. This shuts down the interface and then re-enables it, which might generate messages on the device to which the interface is connected. When you put an interface that is in Layer 3 mode into Layer 2 mode, the previous configuration information related to the affected interface might be lost, and the interface is returned to its default configuration.

Automatic medium-dependent interface crossover (auto-MDIX) is enabled by default.

Auto-MDIX is supported on all 10/100/1000-Mb/s and on 10/100/1000BASE-TX small form-factor pluggable (SFP)-module interfaces. It is not supported on 1000BASE-SX or -LX SFP module interfaces.

## Restrictions for Auto-MDIX

The device might not support a pre-standard powered device—such as Cisco IP phones and access points that do not fully support IEEE 802.3af—if that powered device is connected to the device through a crossover cable. This is regardless of whether auto-MDIX is enabled on the switch port.

# Information About Configuring Auto-MDIX

## Auto-MDIX on an Interface

When automatic medium-dependent interface crossover (auto-MDIX) is enabled on an interface, the interface automatically detects the required cable connection type (straight through or crossover) and configures the connection appropriately. When connecting devices without the auto-MDIX feature, you must use straight-through cables to connect to devices such as servers, workstations, or routers and crossover cables to connect to other devices or repeaters. With auto-MDIX enabled, you can use either type of cable to connect to other devices, and the interface automatically corrects for any incorrect cabling. For more information about cabling requirements, see the hardware installation guide.

This table shows the link states that result from auto-MDIX settings and correct and incorrect cabling.

*Table 7: Link Conditions and Auto-MDIX Settings*

Local Side Auto-MDIX	Remote Side Auto-MDIX	With Correct Cabling	With Incorrect Cabling
On	On	Link up	Link up
On	Off	Link up	Link up
Off	On	Link up	Link up
Off	Off	Link up	Link down

## How to Configure Auto-MDIX

### Configuring Auto-MDIX on an Interface

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode

	Command or Action	Purpose
<b>Step 3</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> Device(config)# <b>interface</b> gigabitethernet 1/0/1	Specifies the physical interface to be configured, and enter interface configuration mode.
<b>Step 4</b>	<b>speed auto</b> <b>Example:</b> Device(config-if)# <b>speed auto</b>	Configures the interface to autonegotiate speed with the connected device.
<b>Step 5</b>	<b>duplex auto</b> <b>Example:</b> Device(config-if)# <b>duplex auto</b>	Configures the interface to autonegotiate duplex mode with the connected device.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Example for Configuring Auto-MDIX

This example shows how to enable auto-MDIX on a port:

```
Device# configure terminal
Device(config)# interface gigabitethernet 1/0/1
Device(config-if)# speed auto
Device(config-if)# duplex auto
Device(config-if)# mdix auto
Device(config-if)# end
```

## Additional References

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

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## Feature History and Information for Auto-MDIX

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.



## CHAPTER 7

# Configuring Ethernet Management Port

- [Prerequisites for Ethernet Management Ports, on page 127](#)
- [Information About the Ethernet Management Port, on page 127](#)
- [How to Configure the Ethernet Management Port, on page 130](#)
- [Additional References for Ethernet Management Ports, on page 131](#)
- [Feature History and Information for Ethernet Management Ports, on page 131](#)

## Prerequisites for Ethernet Management Ports

When connecting a PC to the Ethernet management port, you must first assign an IP address.

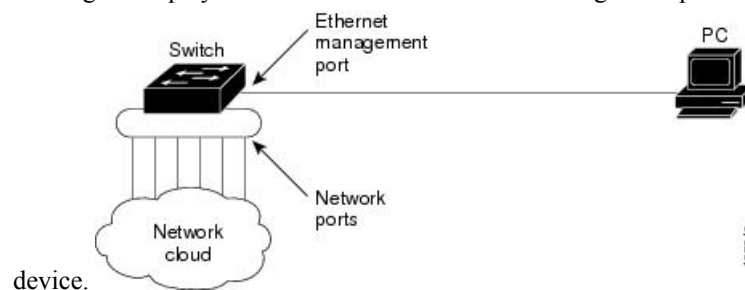
## Information About the Ethernet Management Port

The Ethernet management port, also referred to as the *Gi0/0* or *GigabitEthernet0/0* port, is a VRF (VPN routing/forwarding) interface to which you can connect a PC. You can use the Ethernet management port instead of the device console port for network management. When managing a device stack, connect the PC to the Ethernet management port on a stack member.

## Ethernet Management Port Direct Connection to a Device

**Figure 6: Connecting a Switch to a PC**

This figure displays how to connect the Ethernet management port to the PC for a device or a standalone

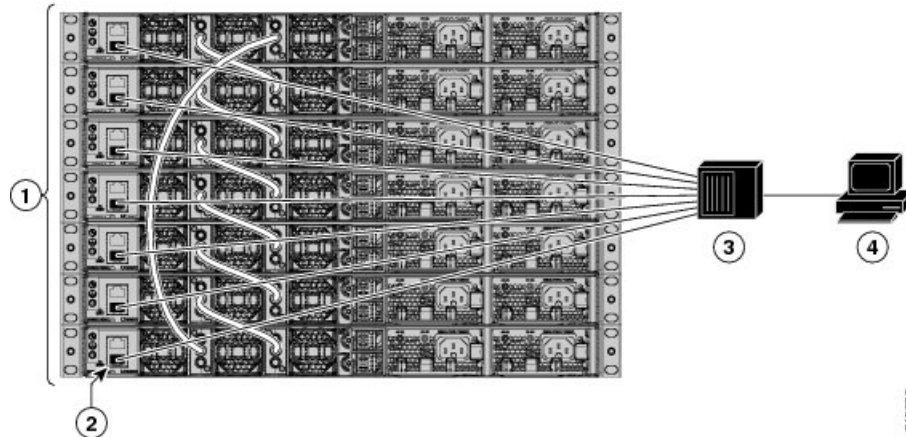


## Ethernet Management Port Connection to Stack Devices using a Hub

In a stack with only stack devices, all the Ethernet management ports on the stack members are connected to a hub to which the PC is connected. The active link is from the Ethernet management port on the active switch through the hub, to the PC. If the active device fails and a new active device is elected, the active link is now from the Ethernet management port on the new active device to the PC.

**Figure 7: Connecting a Device Stack to a PC**

This figure displays how a PC uses a hub to connect to a device stack.



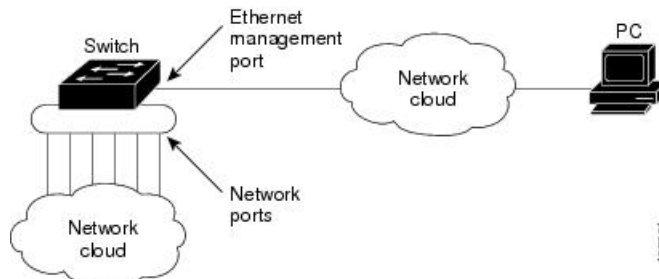
1	Switch stack	3	Hub
2	Management port	4	PC

## Ethernet Management Port and Routing

By default, the Ethernet management port is enabled. The device cannot route packets from the Ethernet management port to a network port, and the reverse. Even though the Ethernet management port does not support routing, you may need to enable routing protocols on the port.

**Figure 8: Network Example with Routing Protocols Enabled**

Enable routing protocols on the Ethernet management port when the PC is multiple hops away from the device and the packets must pass through multiple Layer 3 devices to reach the PC.



In the above figure, if the Ethernet management port and the network ports are associated with the same routing process, the routes are propagated as follows:

- The routes from the Ethernet management port are propagated through the network ports to the network.

- The routes from the network ports are propagated through the Ethernet management port to the network.

Because routing is not supported between the Ethernet management port and the network ports, traffic between these ports cannot be sent or received. If this happens, data packet loops occur between the ports, which disrupt the device and network operation. To prevent the loops, configure route filters to avoid routes between the Ethernet management port and the network ports.

## Supported Features on the Ethernet Management Port

The Ethernet management port supports these features:

- Express Setup (only in switch stacks)
- Network Assistant
- Telnet with passwords
- TFTP
- Secure Shell (SSH)
- DHCP-based autoconfiguration
- SMNP (only the ENTITY-MIB and the IF-MIB)
- IP ping
- Interface features
  - Speed—10 Mb/s, 100 Mb/s, 1000 Mb/s, and autonegotiation
  - Duplex mode—Full, half, and autonegotiation
  - Loopback detection
- Cisco Discovery Protocol (CDP)
- DHCP relay agent
- IPv4 and IPv6 access control lists (ACLs)
- Routing protocols



---

**Caution**

Before enabling a feature on the Ethernet management port, make sure that the feature is supported. If you try to configure an unsupported feature on the Ethernet Management port, the feature might not work properly, and the device might fail.

---

# How to Configure the Ethernet Management Port

## Disabling and Enabling the Ethernet Management Port

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>interface gigabitethernet0/0</b> <b>Example:</b> Device(config)# <code>interface gigabitethernet0/0</code>	Specifies the Ethernet management port in the CLI.
<b>Step 3</b>	<b>shutdown</b> <b>Example:</b> Device(config-if)# <code>shutdown</code>	Disables the Ethernet management port.
<b>Step 4</b>	<b>no shutdown</b> <b>Example:</b> Device(config-if)# <code>no shutdown</code>	Enables the Ethernet management port.
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config-if)# <code>exit</code>	Exits interface configuration mode.
<b>Step 6</b>	<b>show interfaces gigabitethernet0/0</b> <b>Example:</b> Device# <code>show interfaces gigabitethernet0/0</code>	Displays the link status.  To find out the link status to the PC, you can monitor the LED for the Ethernet management port. The LED is green (on) when the link is active, and the LED is off when the link is down. The LED is amber when there is a POST failure.

### What to do next

Proceed to manage or configure your switch using the Ethernet management port. Refer to the *Network Management Configuration Guide (Catalyst 3850 Switches)*.



## Additional References for Ethernet Management Ports

### Related Documents

Related Topic	Document Title
Bootloader configuration	<i>System Management Configuration Guide (Catalyst 3850 Switches)</i>
Bootloader commands	<i>System Management Command Reference (Catalyst 3850 Switches)</i>

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

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Description	Link
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## Feature History and Information for Ethernet Management Ports

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.





## CHAPTER 8

# Configuring LLDP, LLDP-MED, and Wired Location Service

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- [Finding Feature Information, on page 133](#)
- [Information About LLDP, LLDP-MED, and Wired Location Service, on page 133](#)
- [How to Configure LLDP, LLDP-MED, and Wired Location Service, on page 138](#)
- [Configuration Examples for LLDP, LLDP-MED, and Wired Location Service, on page 148](#)
- [Monitoring and Maintaining LLDP, LLDP-MED, and Wired Location Service, on page 148](#)
- [Additional References for LLDP, LLDP-MED, and Wired Location Service, on page 149](#)
- [Feature Information for LLDP, LLDP-MED, and Wired Location Service, on page 150](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About LLDP, LLDP-MED, and Wired Location Service

### LLDP

The Cisco Discovery Protocol (CDP) is a device discovery protocol that runs over Layer 2 (the data link layer) on all Cisco-manufactured devices (routers, bridges, access servers, switches, and controllers). CDP allows network management applications to automatically discover and learn about other Cisco devices connected to the network.

To support non-Cisco devices and to allow for interoperability between other devices, the device supports the IEEE 802.1AB Link Layer Discovery Protocol (LLDP). LLDP is a neighbor discovery protocol that is used for network devices to advertise information about themselves to other devices on the network. This protocol

runs over the data-link layer, which allows two systems running different network layer protocols to learn about each other.

## LLDP Supported TLVs

LLDP supports a set of attributes that it uses to discover neighbor devices. These attributes contain type, length, and value descriptions and are referred to as TLVs. LLDP supported devices can use TLVs to receive and send information to their neighbors. This protocol can advertise details such as configuration information, device capabilities, and device identity.

The switch supports these basic management TLVs. These are mandatory LLDP TLVs.

- Port description TLV
- System name TLV
- System description TLV
- System capabilities TLV
- Management address TLV

These organizationally specific LLDP TLVs are also advertised to support LLDP-MED.

- Port VLAN ID TLV (IEEE 802.1 organizationally specific TLVs)
- MAC/PHY configuration/status TLV (IEEE 802.3 organizationally specific TLVs)

## LLDP and Cisco Device Stacks

A device stack appears as a single device in the network. Therefore, LLDP discovers the device stack, not the individual stack members.

## LLDP-MED

LLDP for Media Endpoint Devices (LLDP-MED) is an extension to LLDP that operates between endpoint devices such as IP phones and network devices. It specifically provides support for voice over IP (VoIP) applications and provides additional TLVs for capabilities discovery, network policy, Power over Ethernet, inventory management and location information. By default, all LLDP-MED TLVs are enabled.

## LLDP-MED Supported TLVs

LLDP-MED supports these TLVs:

- LLDP-MED capabilities TLV

Allows LLDP-MED endpoints to determine the capabilities that the connected device supports and has enabled.

- Network policy TLV

Allows both network connectivity devices and endpoints to advertise VLAN configurations and associated Layer 2 and Layer 3 attributes for the specific application on that port. For example, the switch can notify a phone of the VLAN number that it should use. The phone can connect to any device, obtain its VLAN number, and then start communicating with the call control.

By defining a network-policy profile TLV, you can create a profile for voice and voice-signaling by specifying the values for VLAN, class of service (CoS), differentiated services code point (DSCP), and tagging mode. These profile attributes are then maintained centrally on the switch and propagated to the phone.

- Power management TLV

Enables advanced power management between LLDP-MED endpoint and network connectivity devices. Allows devices and phones to convey power information, such as how the device is powered, power priority, and how much power the device needs.

LLDP-MED also supports an extended power TLV to advertise fine-grained power requirements, end-point power priority, and end-point and network connectivity-device power status. LLDP is enabled and power is applied to a port, the power TLV determines the actual power requirement of the endpoint device so that the system power budget can be adjusted accordingly. The device processes the requests and either grants or denies power based on the current power budget. If the request is granted, the switch updates the power budget. If the request is denied, the device turns off power to the port, generates a syslog message, and updates the power budget. If LLDP-MED is disabled or if the endpoint does not support the LLDP-MED power TLV, the initial allocation value is used throughout the duration of the connection.

You can change power settings by entering the **power inline** {**auto** [**max** *max-wattage*] | **never** | **static** [**max** *max-wattage*]} interface configuration command. By default the PoE interface is in **auto** mode; If no value is specified, the maximum is allowed (30 W).

- Inventory management TLV

Allows an endpoint to send detailed inventory information about itself to the device, including information hardware revision, firmware version, software version, serial number, manufacturer name, model name, and asset ID TLV.

- Location TLV

Provides location information from the device to the endpoint device. The location TLV can send this information:

- Civic location information

Provides the civic address information and postal information. Examples of civic location information are street address, road name, and postal community name information.

- ELIN location information

Provides the location information of a caller. The location is determined by the Emergency location identifier number (ELIN), which is a phone number that routes an emergency call to the local public safety answering point (PSAP) and which the PSAP can use to call back the emergency caller.

- Geographic location information

Provides the geographical details of a switch location such as latitude, longitude, and altitude of a switch.

- custom location

Provides customized name and value of a switch location.

## Wired Location Service

The device uses the location service feature to send location and attachment tracking information for its connected devices to a Cisco Mobility Services Engine (MSE). The tracked device can be a wireless endpoint, a wired endpoint, or a wired device or controller. The device notifies the MSE of device link up and link down events through the Network Mobility Services Protocol (NMSP) location and attachment notifications.

The MSE starts the NMSP connection to the device, which opens a server port. When the MSE connects to the device there are a set of message exchanges to establish version compatibility and service exchange information followed by location information synchronization. After connection, the device periodically sends location and attachment notifications to the MSE. Any link up or link down events detected during an interval are aggregated and sent at the end of the interval.

When the device determines the presence or absence of a device on a link-up or link-down event, it obtains the client-specific information such as the MAC address, IP address, and username. If the client is LLDP-MED- or CDP-capable, the device obtains the serial number and UDI through the LLDP-MED location TLV or CDP.

Depending on the device capabilities, the device obtains this client information at link up:

- Slot and port specified in port connection
- MAC address specified in the client MAC address
- IP address specified in port connection
- 802.1X username if applicable
- Device category is specified as a *wired station*
- State is specified as *new*
- Serial number, UDI
- Model number
- Time in seconds since the device detected the association

Depending on the device capabilities, the device obtains this client information at link down:

- Slot and port that was disconnected
- MAC address
- IP address
- 802.1X username if applicable
- Device category is specified as a *wired station*
- State is specified as *delete*
- Serial number, UDI
- Time in seconds since the device detected the disassociation

When the device shuts down, it sends an attachment notification with the state *delete* and the IP address before closing the NMSP connection to the MSE. The MSE interprets this notification as disassociation for all the wired clients associated with the device.

If you change a location address on the device, the device sends an NMSP location notification message that identifies the affected ports and the changed address information.

## Default LLDP Configuration

*Table 8: Default LLDP Configuration*

Feature	Default Setting
LLDP global state	Disabled
LLDP holdtime (before discarding)	120 seconds
LLDP timer (packet update frequency)	30 seconds
LLDP reinitialization delay	2 seconds
LLDP tlv-select	Disabled to send and receive all TLVs
LLDP interface state	Disabled
LLDP receive	Disabled
LLDP transmit	Disabled
LLDP med-tlv-select	Disabled to send all LLDP-MED TLVs. When LLDP is globally enabled, LLDP-MED-TLV is also enabled.

## Restrictions for LLDP

- If the interface is configured as a tunnel port, LLDP is automatically disabled.
- If you first configure a network-policy profile on an interface, you cannot apply the **switchport voice vlan** command on the interface. If the **switchport voice vlan *vlan-id*** is already configured on an interface, you can apply a network-policy profile on the interface. This way the interface has the voice or voice-signaling VLAN network-policy profile applied on the interface.
- You cannot configure static secure MAC addresses on an interface that has a network-policy profile.
- When Cisco Discovery Protocol and LLDP are both in use within the same switch, it is necessary to disable LLDP on interfaces where Cisco Discovery Protocol is in use for power negotiation. LLDP can be disabled at interface level with the commands **no lldp tlv-select power-management** or **no lldp transmit / no lldp receive**.

# How to Configure LLDP, LLDP-MED, and Wired Location Service

## Enabling LLDP

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>lldp run</b> <b>Example:</b> Device (config)# <b>lldp run</b>	Enables LLDP globally on the device.
<b>Step 4</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device (config)# <b>interface</b> <b>gigabitethernet 2/0/1</b>	Specifies the interface on which you are enabling LLDP, and enter interface configuration mode.
<b>Step 5</b>	<b>lldp transmit</b> <b>Example:</b> Device(config-if)# <b>lldp transmit</b>	Enables the interface to send LLDP packets.
<b>Step 6</b>	<b>lldp receive</b> <b>Example:</b> Device(config-if)# <b>lldp receive</b>	Enables the interface to receive LLDP packets.
<b>Step 7</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.



	Command or Action	Purpose
	<code>Device(config-if)# end</code>	
<b>Step 8</b>	<b>show lldp</b> <b>Example:</b> <code>Device# show lldp</code>	Verifies the configuration.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b> <code>Device# copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring LLDP Characteristics

You can configure the frequency of LLDP updates, the amount of time to hold the information before discarding it, and the initialization delay time. You can also select the LLDP and LLDP-MED TLVs to send and receive.



**Note** Steps 3 through 6 are optional and can be performed in any order.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <code>Device&gt; enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <code>Device# configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>lldp holdtime seconds</b> <b>Example:</b> <code>Device(config)# lldp holdtime 120</code>	(Optional) Specifies the amount of time a receiving device should hold the information from your device before discarding it.  The range is 0 to 65535 seconds; the default is 120 seconds.

	Command or Action	Purpose
<b>Step 4</b>	<b>lldp reinit</b> <i>delay</i> <b>Example:</b> Device (config) # <b>lldp reinit 2</b>	(Optional) Specifies the delay time in seconds for LLDP to initialize on an interface.  The range is 2 to 5 seconds; the default is 2 seconds.
<b>Step 5</b>	<b>lldp timer</b> <i>rate</i> <b>Example:</b> Device (config) # <b>lldp timer 30</b>	(Optional) Sets the sending frequency of LLDP updates in seconds.  The range is 5 to 65534 seconds; the default is 30 seconds.
<b>Step 6</b>	<b>lldp tlv-select</b> <b>Example:</b> Device (config) # <b>tlv-select</b>	(Optional) Specifies the LLDP TLVs to send or receive.
<b>Step 7</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> Device (config) # <b>interface gigabitethernet 2/0/1</b>	Specifies the interface on which you are enabling LLDP, and enter interface configuration mode.
<b>Step 8</b>	<b>lldp med-tlv-select</b> <b>Example:</b> Device (config-if) # <b>lldp med-tlv-select inventory management</b>	(Optional) Specifies the LLDP-MED TLVs to send or receive.
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device (config-if) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 10</b>	<b>show lldp</b> <b>Example:</b> Device# <b>show lldp</b>	Verifies the configuration.
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config</b>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	<code>startup-config</code>	

## Configuring LLDP-MED TLVs

By default, the device only sends LLDP packets until it receives LLDP-MED packets from the end device. It then sends LLDP packets with MED TLVs, as well. When the LLDP-MED entry has been aged out, it again only sends LLDP packets.

By using the `lldp` interface configuration command, you can configure the interface not to send the TLVs listed in the following table.

**Table 9: LLDP-MED TLVs**

LLDP-MED TLV	Description
inventory-management	LLDP-MED inventory management TLV
location	LLDP-MED location TLV
network-policy	LLDP-MED network policy TLV
power-management	LLDP-MED power management TLV

Follow these steps to enable a TLV on an interface:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> <pre>Device (config)# interface gigabitethernet 2/0/1</pre>	Specifies the interface on which you are enabling LLDP, and enter interface configuration mode.

	Command or Action	Purpose
<b>Step 4</b>	<b>lldp med-tlv-select</b> <b>Example:</b> <pre>Device(config-if)# lldp med-tlv-select inventory management</pre>	Specifies the TLV to enable.
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring Network-Policy TLV

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>network-policy profile <i>profile number</i></b> <b>Example:</b> <pre>Device(config)# network-policy profile 1</pre>	Specifies the network-policy profile number, and enter network-policy configuration mode. The range is 1 to 4294967295.
<b>Step 4</b>	<pre>{voice   voice-signaling} vlan [vlan-id {cos cvalue   dscp dvalue}] [[dot1p {cos cvalue   dscp dvalue}]   none   untagged]</pre>	Configures the policy attributes: <ul style="list-style-type: none"> <li>• <b>voice</b>—Specifies the voice application type.</li> </ul>

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config-network-policy)# voice vlan 100 cos 4</pre>	<ul style="list-style-type: none"> <li>• <b>voice-signaling</b>—Specifies the voice-signaling application type.</li> <li>• <b>vlan</b>—Specifies the native VLAN for voice traffic.</li> <li>• <i>vlan-id</i>—(Optional) Specifies the VLAN for voice traffic. The range is 1 to 4094.</li> <li>• <b>cos cvalue</b>—(Optional) Specifies the Layer 2 priority class of service (CoS) for the configured VLAN. The range is 0 to 7; the default is 5.</li> <li>• <b>dscp dvalue</b>—(Optional) Specifies the differentiated services code point (DSCP) value for the configured VLAN. The range is 0 to 63; the default is 46.</li> <li>• <b>dot1p</b>—(Optional) Configures the telephone to use IEEE 802.1p priority tagging and use VLAN 0 (the native VLAN).</li> <li>• <b>none</b>—(Optional) Do not instruct the IP telephone about the voice VLAN. The telephone uses the configuration from the telephone key pad.</li> <li>• <b>untagged</b>—(Optional) Configures the telephone to send untagged voice traffic. This is the default for the telephone.</li> <li>• <b>untagged</b>—(Optional) Configures the telephone to send untagged voice traffic. This is the default for the telephone.</li> </ul>
<b>Step 5</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config)# exit</pre>	Returns to global configuration mode.
<b>Step 6</b>	<p><b>interface interface-id</b></p> <p><b>Example:</b></p> <pre>Device (config)# interface gigabitethernet 2/0/1</pre>	Specifies the interface on which you are configuring a network-policy profile, and enter interface configuration mode.
<b>Step 7</b>	<p><b>network-policy profile number</b></p> <p><b>Example:</b></p>	Specifies the network-policy profile number.

	Command or Action	Purpose
	Device (config-if) # <b>network-policy 1</b>	
<b>Step 8</b>	<b>lldp med-tlv-select network-policy</b> <b>Example:</b> Device (config-if) # <b>lldp med-tlv-select network-policy</b>	Specifies the network-policy TLV.
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 10</b>	<b>show network-policy profile</b> <b>Example:</b> Device# <b>show network-policy profile</b>	Verifies the configuration.
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring Location TLV and Wired Location Service

Beginning in privileged EXEC mode, follow these steps to configure location information for an endpoint and to apply it to an interface.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>location {admin-tag <i>string</i>   civic-location identifier {<i>id</i>   <i>host</i>}   elin-location <i>string</i> identifier <i>id</i>   custom-location identifier {<i>id</i>   <i>host</i>}   geo-location identifier {<i>id</i>   <i>host</i>}}</b>	Specifies the location information for an endpoint. <ul style="list-style-type: none"> <li>• <b>admin-tag</b>—Specifies an administrative tag or site information.</li> </ul>

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config)# location civic-location   identifier 1 Device(config-civic)# number 3550 Device(config-civic)# primary-road-name   "Cisco Way" Device(config-civic)# city "San Jose" Device(config-civic)# state CA Device(config-civic)# building 19 Device(config-civic)# room C6 Device(config-civic)# county "Santa   Clara" Device(config-civic)# country US</pre>	<ul style="list-style-type: none"> <li>• <b>civic-location</b>—Specifies civic location information.</li> <li>• <b>elin-location</b>—Specifies emergency location information (ELIN).</li> <li>• <b>custom-location</b>—Specifies custom location information.</li> <li>• <b>geo-location</b>—Specifies geo-spatial location information.</li> <li>• <b>identifier <i>id</i></b>—Specifies the ID for the civic, ELIN, custom, or geo location.</li> <li>• <b>host</b>—Specifies the host civic, custom, or geo location.</li> <li>• <b><i>string</i></b>—Specifies the site or location information in alphanumeric format.</li> </ul>
<b>Step 3</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-civic)# exit</pre>	Returns to global configuration mode.
<b>Step 4</b>	<p><b>interface <i>interface-id</i></b></p> <p><b>Example:</b></p> <pre>Device (config)# interface   gigabitethernet2/0/1</pre>	Specifies the interface on which you are configuring the location information, and enter interface configuration mode.
<b>Step 5</b>	<p><b>location {additional-location-information <i>word</i>   civic-location-id {<i>id</i>   <i>host</i>}   elin-location-id <i>id</i>   custom-location-id {<i>id</i>   <i>host</i>}   geo-location-id {<i>id</i>   <i>host</i>} }</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# location   elin-location-id 1</pre>	<p>Enters location information for an interface:</p> <ul style="list-style-type: none"> <li>• <b>additional-location-information</b>—Specifies additional information for a location or place.</li> <li>• <b>civic-location-id</b>—Specifies global civic location information for an interface.</li> <li>• <b>elin-location-id</b>—Specifies emergency location information for an interface.</li> <li>• <b>custom-location-id</b>—Specifies custom location information for an interface.</li> <li>• <b>geo-location-id</b>—Specifies geo-spatial location information for an interface.</li> <li>• <b>host</b>—Specifies the host location identifier.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <i>word</i>—Specifies a word or phrase with additional location information.</li> <li>• <i>id</i>—Specifies the ID for the civic, ELIN, custom, or geo location. The ID range is 1 to 4095.</li> </ul>
<b>Step 6</b>	<b>end</b> <b>Example:</b> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.
<b>Step 7</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>show location admin-tag</b> <i>string</i></li> <li>• <b>show location civic-location identifier</b> <i>id</i></li> <li>• <b>show location elin-location identifier</b> <i>id</i></li> </ul> <b>Example:</b> <pre>Device# show location admin-tag</pre> OR <pre>Device# show location civic-location identifier</pre> OR <pre>Device# show location elin-location identifier</pre>	Verifies the configuration.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Enabling Wired Location Service on the Device

### Before you begin

For wired location to function, you must first enter the **ip device tracking** global configuration command.



## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>nmosp notification interval {attachment   location} interval-seconds</b> <b>Example:</b> <pre>Device(config)# nmosp notification interval location 10</pre>	Specifies the NMSP notification interval. <b>attachment</b> —Specifies the attachment notification interval. <b>location</b> —Specifies the location notification interval. <i>interval-seconds</i> —Duration in seconds before the device sends the MSE the location or attachment updates. The range is 1 to 30; the default is 30.
<b>Step 4</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show network-policy profile</b> <b>Example:</b> <pre>Device# show network-policy profile</pre>	Verifies the configuration.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

# Configuration Examples for LLDP, LLDP-MED, and Wired Location Service

## Configuring Network-Policy TLV: Examples

This example shows how to configure VLAN 100 for voice application with CoS and to enable the network-policy profile and network-policy TLV on an interface:

```
# configure terminal
(config)# network-policy 1
(config-network-policy)# voice vlan 100 cos 4
(config-network-policy)# exit
(config)# interface gigabitethernet 1/0/1
(config-if)# network-policy profile 1
(config-if)# lldp med-tlv-select network-policy
```

This example shows how to configure the voice application type for the native VLAN with priority tagging:

```
config-network-policy)# voice vlan dot1p cos 4
config-network-policy)# voice vlan dot1p dscp 34
```

## Monitoring and Maintaining LLDP, LLDP-MED, and Wired Location Service

Commands for monitoring and maintaining LLDP, LLDP-MED, and wired location service.

Command	Description
<code>clear lldp counters</code>	Resets the traffic counters to zero.
<code>clear lldp table</code>	Deletes the LLDP neighbor information table.
<code>clear nmosp statistics</code>	Clears the NMSP statistic counters.
<code>show lldp</code>	Displays global information, such as frequency of transmissions, the holdtime for packets being sent, and the delay time before LLDP initializes on an interface.
<code>show lldp entry <i>entry-name</i></code>	Displays information about a specific neighbor. You can enter an asterisk (*) to display all neighbors, or you can enter the neighbor name.

Command	Description
<b>show lldp interface</b> [ <i>interface-id</i> ]	Displays information about interfaces with LLDP enabled.  You can limit the display to a specific interface.
<b>show lldp neighbors</b> [ <i>interface-id</i> ] [ <b>detail</b> ]	Displays information about neighbors, including device type, interface type and number, holdtime settings, capabilities, and port ID.  You can limit the display to neighbors of a specific interface or expand the display for more detailed information.
<b>show lldp traffic</b>	Displays LLDP counters, including the number of packets sent and received, number of packets discarded, and number of unrecognized TLVs.
<b>show location admin-tag</b> <i>string</i>	Displays the location information for the specified administrative tag or site.
<b>show location civic-location identifier</b> <i>id</i>	Displays the location information for a specific global civic location.
<b>show location elin-location identifier</b> <i>id</i>	Displays the location information for an emergency location
<b>show network-policy profile</b>	Displays the configured network-policy profiles.
<b>show nmosp</b>	Displays the NMSP information

## Additional References for LLDP, LLDP-MED, and Wired Location Service

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for LLDP, LLDP-MED, and Wired Location Service

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.



## CHAPTER 9

# Configuring System MTU

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- [How to Configure MTU Sizes, on page 152](#)
- [Configuration Examples for System MTU, on page 154](#)
- [Configuration Examples for System MTU, on page 154](#)
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- [Information About the MTU, on page 155](#)
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- [Feature Information for System MTU, on page 159](#)

## Information About the MTU

The default maximum transmission unit (MTU) size for frames received and sent on all device interfaces is 1500 bytes.

## Restrictions for System MTU

When configuring the system MTU values, follow these guidelines:

- The device does not support the MTU on a per-interface basis.
- If you enter the **system mtu bytes** global configuration command, the command affects all the switched and routed ports on the switch.

## System MTU Value Application

In a switch stack, the MTU values applied to member switches depends upon the stack configuration. The following stack configurations are supported:

This table shows how the MTU values are applied.

**Table 10: MTU Values**

Configuration	system mtu command	ip mtu command	ipv6 mtu command
Standalone switch	<p>You can enter the <b>system mtu</b> command on a switch, but system MTU value does not take effect on the switch. It affects the Fast Ethernet ports.</p> <p>The range is from 1500 to 9198 bytes.</p>	<p>Use the <b>ip mtu bytes</b> command.</p> <p>The range is from 832 up to 1500 bytes.</p> <p><b>Note</b> The IP MTU value is the applied value, not the configured value.</p>	<p>Use the <b>ipv6 mtu bytes</b> command.</p> <p>The range is from 1280 to the system jumbo MTU value (in bytes).</p> <p><b>Note</b> The IPv6 MTU value is the applied value, not the configured value.</p>

The upper limit of the IP or IPv6 MTU value is based on the switch configuration and refers to the currently applied system MTU value. For more information about setting the MTU sizes, see the **system mtu** global configuration command in the command reference for this release.

## How to Configure MTU Sizes

### Configuring the System MTU

Follow these steps to change the MTU size for switched packets:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	<p>Enters global configuration mode.</p>
<b>Step 3</b>	<p><b>system mtu bytes</b></p> <p><b>Example:</b></p> <pre>Device(config)# system mtu 1900</pre>	<p>(Optional) Changes the MTU size for all Gigabit Ethernet and 10-Gigabit Ethernet interfaces.</p>
<b>Step 4</b>	<p><b>end</b></p> <p><b>Example:</b></p>	<p>Returns to privileged EXEC mode.</p>

	Command or Action	Purpose
	Device(config)# <b>end</b>	
<b>Step 5</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	Saves your entries in the configuration file.
<b>Step 6</b>	<b>show system mtu</b> <b>Example:</b> Device# <b>show system mtu</b>	Verifies your settings.

## Configuring Protocol-Specific MTU

To override system MTU values on routed interfaces, configure protocol-specific MTU under each routed interface.

Beginning in privileged EXEC mode, follow these steps to change the MTU size for routed ports:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet0/0</b>	Enters interface configuration mode.
<b>Step 3</b>	<b>ip mtu <i>bytes</i></b> <b>Example:</b> Device(config-if)# <b>ip mtu 68</b>	Changes the IPv4 MTU size
<b>Step 4</b>	<b>ipv6 mtu <i>bytes</i></b> <b>Example:</b> Device(config-if)# <b>ipv6 mtu 1280</b>	(Optional) Changes the IPv6 MTU size.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>	Saves your entries in the configuration file.

	Command or Action	Purpose
	Device# <code>copy running-config startup-config</code>	
<b>Step 7</b>	<b>show system mtu</b>  <b>Example:</b> Device# <code>show system mtu</code>	Verifies your settings.

## Configuration Examples for System MTU

This example shows how to set the maximum packet size for a Gigabit Ethernet port to 7500 bytes:

```
Device(config)# system mtu 7500
Device(config)#
Device(config)# exit
```

If you enter a value that is outside the allowed range for the specific type of interface, the value is not accepted. This example shows the response when you try to set Gigabit Ethernet interfaces to an out-of-range number:

```
Device(config)# system mtu 25000
                        ^
% Invalid input detected at '^' marker.
```

## Configuration Examples for System MTU

### Example: Configuring Protocol-Specific MTU

```
Device# configure terminal
Device(config)# interface gigabitethernet 0/0
Device(config-if)# ip mtu 900
Device(config-if)# ipv6 mtu 1286
Device(config-if)# end
```

### Example: Configuring the System MTU

```
Device# configure terminal
Device(config)# system mtu 1600
Device(config)# exit
```



## Additional References for System MTU

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for System MTU

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.

## Information About the MTU

The default maximum transmission unit (MTU) size for frames received and sent on all device interfaces is 1500 bytes.

## Restrictions for System MTU

When configuring the system MTU values, follow these guidelines:

- The device does not support the MTU on a per-interface basis.
- If you enter the **system mtu bytes** global configuration command, the command affects all the switched and routed ports on the switch.

## System MTU Value Application

In a switch stack, the MTU values applied to member switches depends upon the stack configuration. The following stack configurations are supported:

This table shows how the MTU values are applied.

**Table 11: MTU Values**

Configuration	system mtu command	ip mtu command	ipv6 mtu command
Standalone switch	<p>You can enter the <b>system mtu</b> command on a switch , but system MTU value does not take effect on the switch. It affects the Fast Ethernet ports.</p> <p>The range is from 1500 to 9198 bytes.</p>	<p>Use the <b>ip mtu bytes</b> command.</p> <p>The range is from 832 up to 1500 bytes.</p> <p><b>Note</b> The IP MTU value is the applied value, not the configured value.</p>	<p>Use the <b>ipv6 mtu bytes</b> command.</p> <p>The range is from 1280 to the system jumbo MTU value (in bytes).</p> <p><b>Note</b> The IPv6 MTU value is the applied value, not the configured value.</p>

The upper limit of the IP or IPv6 MTU value is based on the switch configuration and refers to the currently applied system MTU value. For more information about setting the MTU sizes, see the **system mtu** global configuration command in the command reference for this release.

## How to Configure MTU Sizes

### Configuring the System MTU

Follow these steps to change the MTU size for switched packets:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	<p>Enters global configuration mode.</p>

	Command or Action	Purpose
<b>Step 3</b>	<b>system mtu bytes</b> <b>Example:</b> Device(config)# <b>system mtu 1900</b>	(Optional) Changes the MTU size for all Gigabit Ethernet and 10-Gigabit Ethernet interfaces.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	Saves your entries in the configuration file.
<b>Step 6</b>	<b>show system mtu</b> <b>Example:</b> Device# <b>show system mtu</b>	Verifies your settings.

## Configuring Protocol-Specific MTU

To override system MTU values on routed interfaces, configure protocol-specific MTU under each routed interface.

Beginning in privileged EXEC mode, follow these steps to change the MTU size for routed ports:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface interface</b> <b>Example:</b> Device(config)# <b>interface gigabitethernet0/0</b>	Enters interface configuration mode.
<b>Step 3</b>	<b>ip mtu bytes</b> <b>Example:</b> Device(config-if)# <b>ip mtu 68</b>	Changes the IPv4 MTU size
<b>Step 4</b>	<b>ipv6 mtu bytes</b> <b>Example:</b> Device(config-if)# <b>ipv6 mtu 1280</b>	(Optional) Changes the IPv6 MTU size.

	Command or Action	Purpose
<b>Step 5</b>	<b>end</b>  <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>copy running-config startup-config</b>  <b>Example:</b> Device# <b>copy running-config startup-config</b>	Saves your entries in the configuration file.
<b>Step 7</b>	<b>show system mtu</b>  <b>Example:</b> Device# <b>show system mtu</b>	Verifies your settings.

## Configuration Examples for System MTU

This example shows how to set the maximum packet size for a Gigabit Ethernet port to 7500 bytes:

```
Device(config)# system mtu 7500
Device(config)#
Device(config)# exit
```

If you enter a value that is outside the allowed range for the specific type of interface, the value is not accepted. This example shows the response when you try to set Gigabit Ethernet interfaces to an out-of-range number:

```
Device(config)# system mtu 25000
                        ^
% Invalid input detected at '^' marker.
```

## Configuration Examples for System MTU

### Example: Configuring Protocol-Specific MTU

```
Device# configure terminal
Device(config)# interface gigabitethernet 0/0
Device(config-if)# ip mtu 900
Device(config-if)# ipv6 mtu 1286
Device(config-if)# end
```

## Example: Configuring the System MTU

```
Device# configure terminal
Device(config)# system mtu 1600
Device(config)# exit
```

## Additional References for System MTU

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for System MTU

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.





# CHAPTER 10

## Configuring Internal Power Supplies

- [Information About Internal Power Supplies](#) , on page 161
- [How to Configure Internal Power Supplies](#), on page 161
- [Monitoring Internal Power Supplies](#), on page 162
- [Configuration Examples for Internal Power Supplies](#), on page 162
- [Additional References](#), on page 163
- [Feature History and Information for Internal Power Supplies](#), on page 164

### Information About Internal Power Supplies

See the device installation guide for information about the power supplies.

### How to Configure Internal Power Supplies

#### Configuring Internal Power Supply

You can use the **power supply** EXEC command to configure and manage the internal power supply on the device. The device does not support the **no power supply** EXEC command.

Follow these steps beginning in user EXEC mode:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<pre>power supply <i>switch_number</i> slot{A   B} { off   on }  Example:  Device# power supply 1 slot A on</pre>	<p>Sets the specified power supply to <b>off</b> or <b>on</b> by using one of these keywords:</p> <ul style="list-style-type: none"><li>• <b>A</b> —Selects the power supply in slot A.</li><li>• <b>B</b> —Selects power supply in slot B.</li></ul> <p><b>Note</b> Power supply slot B is the closest to the outer edge of the device.</p>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>off</b> —Set the power supply off.</li> <li>• <b>on</b> —Set the power supply on.</li> </ul> <p>By default, the device power supply is <b>on</b>.</p>
<b>Step 2</b>	<b>show environment power</b>  <b>Example:</b>  Device# <b>show environment power</b>	Verifies your settings.

## Monitoring Internal Power Supplies

Table 12: Show Commands for Power Supplies

Command	Purpose
<b>show environment power</b> [ <b>all</b>   <b>switch</b> <i>switch_number</i> ]	(Optional) Displays the status of the internal power supplies for the specified device. .  The device keywords are available only on stacking-capable devices.

## Configuration Examples for Internal Power Supplies

This example shows how to set the power supply in slot A to off:

```
Device# power supply 1 slot A off
Disabling Power supply A may result in a power loss to PoE devices and/or switches ...
Continue? (yes/[no]): yes
Device#
Jun 10 04:52:54.389: %PLATFORM_ENV-6-FRU_PS_OIR: FRU Power Supply 1 powered off
Jun 10 04:52:56.717: %PLATFORM_ENV-1-FAN_NOT_PRESENT: Fan is not present
Device#
```

This example shows how to set the power supply in slot A to on:

```
Device# power supply 1 slot A on
Jun 10 04:54:39.600: %PLATFORM_ENV-6-FRU_PS_OIR: FRU Power Supply 1 powered on
```

This example shows the output of the **show env power** command:

```
Device# show env power

SW  PID                Serial#      Status      Sys Pwr  PoE Pwr  Watts
---  -
1A  PWR-C1-715WAC      LIT161010UE OK           Good      Good      715
```



```
1B Not Present
```

```
Device#
```

**Table 13: show env power Status Descriptions**

Field	Description
OK	The power supply is present and power is good.
Not Present	No power supply is installed.
No Input Power	The power supply is present but there is no input power.
Disabled	The power supply and input power are present, but power supply is switched off by CLI.
Not Responding	The power supply is not recognizable or is faulty.
Failure-Fan	The power supply fan is faulty.

## Additional References

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for Internal Power Supplies

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.
Cisco IOS XE 3.3SE	The <b>slot</b> keyword replaced the <b>frufep</b> keyword.



# CHAPTER 11

## Configuring PoE

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- [Information About PoE, on page 165](#)
- [How to Configure PoE, on page 170](#)
- [Monitoring Power Status, on page 175](#)
- [Additional References, on page 175](#)
- [Feature Information for PoE, on page 176](#)

## Information About PoE

### Power over Ethernet Ports

A PoE-capable switch port automatically supplies power to one of these connected devices if the device senses that there is no power on the circuit:

- a Cisco pre-standard powered device (such as a Cisco IP Phone or a Cisco Aironet Access Point)
- an IEEE 802.3af-compliant powered device

A powered device can receive redundant power when it is connected to a PoE switch port and to an AC power source. The device does not receive redundant power when it is only connected to the PoE port.

### Supported Protocols and Standards

The device uses these protocols and standards to support PoE:

- CDP with power consumption—The powered device notifies the device of the amount of power it is consuming. The device does not reply to the power-consumption messages. The device can only supply power to or remove power from the PoE port.
- Cisco intelligent power management—The powered device and the device negotiate through power-negotiation CDP messages for an agreed-upon power-consumption level. The negotiation allows a high-power Cisco powered device, which consumes more than 7 W, to operate at its highest power mode. The powered device first boots up in low-power mode, consumes less than 7 W, and negotiates to obtain enough power to operate in high-power mode. The device changes to high-power mode only when it receives confirmation from the device.

High-power devices can operate in low-power mode on devices that do not support power-negotiation CDP.

Cisco intelligent power management is backward-compatible with CDP with power consumption; the device responds according to the CDP message that it receives. CDP is not supported on third-party powered devices; therefore, the device uses the IEEE classification to determine the power usage of the device.

- IEEE 802.3af—The major features of this standard are powered-device discovery, power administration, disconnect detection, and optional powered-device power classification. For more information, see the standard.
- IEEE 802.3at—The PoE+ standard increases the maximum power that can be drawn by a powered device from 15.4 W per port to 30 W per port.
- The Cisco UPOE feature provides the capability to source up to 60 W of power (2 x 30 W) over both signal and spare pairs of the RJ-45 Ethernet cable by using the Layer-2 power negotiation protocols such as CDP or LLDP. An LLDP and CDP request of 30 W and higher in presence of the 4-wire Cisco Proprietary spare-pair power TLV can provide power on the spare pair.

## Powered-Device Detection and Initial Power Allocation

The device detects a Cisco pre-standard or an IEEE-compliant powered device when the PoE-capable port is in the no-shutdown state, PoE is enabled (the default), and the connected device is not being powered by an AC adaptor.

After device detection, the device determines the device power requirements based on its type:

- The initial power allocation is the maximum amount of power that a powered device requires. The device initially allocates this amount of power when it detects and powers the powered device. As the device receives CDP messages from the powered device and as the powered device negotiates power levels with the device through CDP power-negotiation messages, the initial power allocation might be adjusted.
- The device classifies the detected IEEE device within a power consumption class. Based on the available power in the power budget, the device determines if a port can be powered. [Table 14: IEEE Power Classifications](#), on page 166 lists these levels.

**Table 14: IEEE Power Classifications**

Class	Maximum Power Level Required from the Device
0 (class status unknown)	15.4 W
1	4 W
2	7 W
3	15.4 W
4	30 W (For IEEE 802.3at Type 2 powered devices)

The device monitors and tracks requests for power and grants power only when it is available. The device tracks its power budget (the amount of power available on the device for PoE). The device performs power-accounting calculations when a port is granted or denied power to keep the power budget up to date.

After power is applied to the port, the device uses CDP to determine the *CDP-specific* power consumption requirement of the connected Cisco powered devices, which is the amount of power to allocate based on the CDP messages. The device adjusts the power budget accordingly. This does not apply to third-party PoE

devices. The device processes a request and either grants or denies power. If the request is granted, the device updates the power budget. If the request is denied, the device ensures that power to the port is turned off, generates a syslog message, and updates the LEDs. Powered devices can also negotiate with the device for more power.

With PoE+, powered devices use IEEE 802.3at and LLDP power with media dependent interface (MDI) type, length, and value descriptions (TLVs), Power-via-MDI TLVs, for negotiating power up to 30 W. Cisco pre-standard devices and Cisco IEEE powered devices can use CDP or the IEEE 802.3at power-via-MDI power negotiation mechanism to request power levels up to 30 W.



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**Note** The initial allocation for Class 0, Class 3, and Class 4 powered devices is 15.4 W. When a device starts up and uses CDP or LLDP to send a request for more than 15.4 W, it can be allocated up to the maximum of 30 W.

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**Note** The CDP-specific power consumption requirement is referred to as the *actual* power consumption requirement in the software configuration guides and command references.

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If the device detects a fault caused by an undervoltage, overvoltage, overtemperature, oscillator-fault, or short-circuit condition, it turns off power to the port, generates a syslog message, and updates the power budget and LEDs.

The PoE feature operates the same whether or not the device is a stack member. The power budget is per device and independent of any other device in the stack. Election of a new active device does not affect PoE operation. The active device keeps track of the PoE status for all devices and ports in the stack and includes the status in output displays.

The stacking-capable device also supports StackPower, which allows the power supplies to share the load across multiple systems in a stack when you connect the devices with power stack cables. You can manage the power supplies of up to four stack members as a one large power supply.

## Power Management Modes

The device supports these PoE modes:

- **auto**—The device automatically detects if the connected device requires power. If the device discovers a powered device connected to the port and if the device has enough power, it grants power, updates the power budget, turns on power to the port on a first-come, first-served basis, and updates the LEDs. For LED information, see the hardware installation guide.

If the device has enough power for all the powered devices, they all come up. If enough power is available for all powered devices connected to the device, power is turned on to all devices. If there is not enough available PoE, or if a device is disconnected and reconnected while other devices are waiting for power, it cannot be determined which devices are granted or are denied power.

If granting power would exceed the system power budget, the device denies power, ensures that power to the port is turned off, generates a syslog message, and updates the LEDs. After power has been denied, the device periodically rechecks the power budget and continues to attempt to grant the request for power.

If a device being powered by the device is then connected to wall power, the device might continue to power the device. The device might continue to report that it is still powering the device whether the device is being powered by the device or receiving power from an AC power source.

If a powered device is removed, the device automatically detects the disconnect and removes power from the port. You can connect a nonpowered device without damaging it.

You can specify the maximum wattage that is allowed on the port. If the IEEE class maximum wattage of the powered device is greater than the configured maximum value, the device does not provide power to the port. If the device powers a powered device, but the powered device later requests through CDP messages more than the configured maximum value, the device removes power to the port. The power that was allocated to the powered device is reclaimed into the global power budget. If you do not specify a wattage, the device delivers the maximum value. Use the **auto** setting on any PoE port. The auto mode is the default setting.

- **static**—The device pre-allocates power to the port (even when no powered device is connected) and guarantees that power will be available for the port. The device allocates the port configured maximum wattage, and the amount is never adjusted through the IEEE class or by CDP messages from the powered device. Because power is pre-allocated, any powered device that uses less than or equal to the maximum wattage is guaranteed to be powered when it is connected to the static port. The port no longer participates in the first-come, first-served model.

However, if the powered-device IEEE class is greater than the maximum wattage, the device does not supply power to it. If the device learns through CDP messages that the powered device is consuming more than the maximum wattage, the device shuts down the powered device.

If you do not specify a wattage, the device pre-allocates the maximum value. The device powers the port only if it discovers a powered device. Use the **static** setting on a high-priority interface.

- **never**—The device disables powered-device detection and never powers the PoE port even if an unpowered device is connected. Use this mode only when you want to make sure that power is never applied to a PoE-capable port, making the port a data-only port.

For most situations, the default configuration (auto mode) works well, providing plug-and-play operation. No further configuration is required. However, perform this task to configure a PoE port for a higher priority, to make it data only, or to specify a maximum wattage to disallow high-power powered devices on a port.

Stacking-capable devices also support StackPower, which allows device power supplies to share the load across multiple systems in a stack by connecting up to four devices with power stack cables.

## Power Monitoring and Power Policing

When policing of the real-time power consumption is enabled, the device takes action when a powered device consumes more power than the maximum amount allocated, also referred to as the *cutoff-power value*.

When PoE is enabled, the device senses the real-time power consumption of the powered device. The device monitors the real-time power consumption of the connected powered device; this is called *power monitoring* or *power sensing*. The device also polices the power usage with the *power policing* feature.

Power monitoring is backward-compatible with Cisco intelligent power management and CDP-based power consumption. It works with these features to ensure that the PoE port can supply power to the powered device.

The device senses the real-time power consumption of the connected device as follows:

1. The device monitors the real-time power consumption on individual ports.
2. The device records the power consumption, including peak power usage. The device reports the information through the CISCO-POWER-ETHERNET-EXT-MIB.

3. If power policing is enabled, the device polices power usage by comparing the real-time power consumption to the maximum power allocated to the device. The maximum power consumption is also referred to as the *cutoff power* on a PoE port.

If the device uses more than the maximum power allocation on the port, the device can either turn off power to the port, or the device can generate a syslog message and update the LEDs (the port LED is now blinking amber) while still providing power to the device based on the device configuration. By default, power-usage policing is disabled on all PoE ports.

If error recovery from the PoE error-disabled state is enabled, the device automatically takes the PoE port out of the error-disabled state after the specified amount of time.

If error recovery is disabled, you can manually re-enable the PoE port by using the **shutdown** and **no shutdown** interface configuration commands.

4. If policing is disabled, no action occurs when the powered device consumes more than the maximum power allocation on the PoE port, which could adversely affect the device.

## Power Consumption Values

You can configure the initial power allocation and the maximum power allocation on a port. However, these values are only the configured values that determine when the device should turn on or turn off power on the PoE port. The maximum power allocation is not the same as the actual power consumption of the powered device. The actual cutoff power value that the device uses for power policing is not equal to the configured power value.

When power policing is enabled, the device polices the power usage *at the switch port*, which is greater than the power consumption of the device. When you manually set the maximum power allocation, you must consider the power loss over the cable from the switch port to the powered device. The cutoff power is the sum of the rated power consumption of the powered device and the worst-case power loss over the cable.

We recommend that you enable power policing when PoE is enabled on your device. For example, if policing is disabled and you set the cutoff-power value by using the **power inline auto max 6300** interface configuration command, the configured maximum power allocation on the PoE port is 6.3 W (6300 mW). The device provides power to the connected devices on the port if the device needs up to 6.3 W. If the CDP-power negotiated value or the IEEE classification value exceeds the configured cutoff value, the device does not provide power to the connected device. After the device turns on power on the PoE port, the device does not police the real-time power consumption of the device, and the device can consume more power than the maximum allocated amount, which could adversely affect the device and the devices connected to the other PoE ports.

Because a standalone device supports internal power supplies, the total amount of power available for the powered devices varies depending on the power supply configuration.

- If a power supply is removed and replaced by a new power supply with less power and the device does not have enough power for the powered devices, the device denies power to the PoE ports in auto mode in descending order of the port numbers. If the device still does not have enough power, the device then denies power to the PoE ports in static mode in descending order of the port numbers.
- If the new power supply supports more power than the previous one and the device now has more power available, the device grants power to the PoE ports in static mode in ascending order of the port numbers. If it still has power available, the device then grants power to the PoE ports in auto mode in ascending order of the port numbers.

The stacking-capable device also supports StackPower, which allows power supplies to share the load across multiple systems in a stack by connecting the devices with power stack cables. You can collectively manage the power supplies of up to four stack members as one large power supply.

## Cisco Universal Power Over Ethernet

Cisco Universal Power Over Ethernet (Cisco UPOE) is a Cisco proprietary technology that extends the IEEE 802.3at PoE standard to provide the capability to source up to 60 W of power over standard Ethernet cabling infrastructure (Class D or better) by using the spare pair of an RJ-45 cable (wires 4,5,7,8) with the signal pair (wires 1,2,3,6). Power on the spare pair is enabled when the switch port and end device mutually identify themselves as Cisco UPOE-capable using CDP or LLDP and the end device requests for power to be enabled on the spare pair. When the spare pair is powered, the end device can negotiate up to 60 W of power from the switch using CDP or LLDP.

If the end device is PoE-capable on both signal and spare pairs but does not support the CDP or LLDP extensions required for Cisco UPOE, a 4-pair forced mode configuration automatically enables power on both signal and spare pairs from the switch port.

## How to Configure PoE

### Configuring a Power Management Mode on a PoE Port



#### Note

When you make PoE configuration changes, the port being configured drops power. Depending on the new configuration, the state of the other PoE ports, and the state of the power budget, the port might not be powered up again. For example, port 1 is in the auto and on state, and you configure it for static mode. The device removes power from port 1, detects the powered device, and repowers the port. If port 1 is in the auto and on state and you configure it with a maximum wattage of 10 W, the device removes power from the port and then redetects the powered device. The device repowers the port only if the powered device is a class 1, class 2, or a Cisco-only powered device.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.



	Command or Action	Purpose
<b>Step 3</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> Device(config)# <b>interface</b> gigabitethernet 2/0/1	Specifies the physical port to be configured, and enters interface configuration mode.
<b>Step 4</b>	<b>power inline</b> { <b>auto</b> [ <b>max</b> <i>max-wattage</i> ]   <b>never</b>   <b>static</b> [ <b>max</b> <i>max-wattage</i> ]} <b>Example:</b> Device(config-if)# <b>power inline auto</b>	Configures the PoE mode on the port. The keywords have these meanings: <ul style="list-style-type: none"> <li>• <b>auto</b>—Enables powered-device detection. If enough power is available, automatically allocates power to the PoE port after device detection. This is the default setting.</li> <li>• <b>max</b> <i>max-wattage</i>—Limits the power allowed on the port. The range for Cisco UPOE ports is 4000 to 60000 mW. If no value is specified, the maximum is allowed.</li> <li>• <b>never</b> —Disables device detection, and disable power to the port.</li> </ul> <p><b>Note</b> If a port has a Cisco powered device connected to it, do not use the <b>power inline never</b> command to configure the port. A false link-up can occur, placing the port into the error-disabled state.</p> <ul style="list-style-type: none"> <li>• <b>static</b>—Enables powered-device detection. Pre-allocate (reserve) power for a port before the device discovers the powered device. The device reserves power for this port even when no device is connected and guarantees that power will be provided upon device detection.</li> </ul> <p>The device allocates power to a port configured in static mode before it allocates power to a port configured in auto mode.</p>
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show power inline</b> [ <i>interface-id</i>   <b>module</b> <i>switch-number</i> ] <b>Example:</b> Device# <b>show power inline</b>	Displays PoE status for a device or a device stack, for the specified interface, or for a specified stack member..  The <b>module</b> <i>switch-number</i> keywords are supported only on stacking-capable devices.

	Command or Action	Purpose
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Enabling Power on Signal/Spare Pairs



**Note** Do not enter this command if the end device cannot source inline power on the spare pair or if the end device supports the CDP or LLDP extensions for Cisco UPOE.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet2/0/1</b>	Specifies the physical port to be configured, and enters interface configuration mode.
<b>Step 3</b>	<b>power inline four-pair forced</b> <b>Example:</b> Device(config-if)# <b>power inline four-pair forced</b>	Enables power on both signal and spare pairs from a switch port.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring Power Policing

By default, the device monitors the real-time power consumption of connected powered devices. You can configure the device to police the power usage. By default, policing is disabled.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 2/0/1</b>	Specifies the physical port to be configured, and enter interface configuration mode.
<b>Step 4</b>	<b>power inline police [action {log   errdisable}]</b> <b>Example:</b> Device(config-if)# <b>power inline police</b>	<p>If the real-time power consumption exceeds the maximum power allocation on the port, configures the device to take one of these actions:</p> <ul style="list-style-type: none"> <li>• <b>power inline police</b>—Shuts down the PoE port, turns off power to it, and puts it in the error-disabled state.</li> </ul> <p><b>Note</b> You can enable error detection for the PoE error-disabled cause by using the <b>errdisable detect cause inline-power</b> global configuration command. You can also enable the timer to recover from the PoE error-disabled state by using the <b>errdisable recovery cause inline-power interval <i>interval</i></b> global configuration command.</p> <ul style="list-style-type: none"> <li>• <b>power inline police action errdisable</b>—Turns off power to the port if the real-time power consumption exceeds the maximum power allocation on the port.</li> <li>• <b>power inline police action log</b>—Generates a syslog message while still providing power to the port.</li> </ul> <p>If you do not enter the <b>action log</b> keywords, the default action shuts down the port and puts the port in the error-disabled state.</p>

	Command or Action	Purpose
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config-if)# <b>exit</b>	Returns to global configuration mode.
<b>Step 6</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>errdisable detect cause inline-power</b></li> <li>• <b>errdisable recovery cause inline-power</b></li> <li>• <b>errdisable recovery interval <i>interval</i></b></li> </ul> <b>Example:</b> Device(config)# <b>errdisable detect cause inline-power</b>  Device(config)# <b>errdisable recovery cause inline-power</b>  Device(config)# <b>errdisable recovery interval 100</b>	(Optional) Enables error recovery from the PoE error-disabled state, and configures the PoE recover mechanism variables.  By default, the recovery interval is 300 seconds.  For <b>interval <i>interval</i></b> , specifies the time in seconds to recover from the error-disabled state. The range is 30 to 86400.
<b>Step 7</b>	<b>exit</b> <b>Example:</b> Device(config)# <b>exit</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>show power inline police</b></li> <li>• <b>show errdisable recovery</b></li> </ul> <b>Example:</b> Device# <b>show power inline police</b>  Device# <b>show errdisable recovery</b>	Displays the power monitoring status, and verify the error recovery settings.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

# Monitoring Power Status

Table 15: Show Commands for Power Status

Command	Purpose
<b>show env power switch</b> [ <i>switch-number</i> ]	(Optional) Displays the status of the internal power supplies for each switch in the stack or for the specified switch.  The range is 1 to 9, depending on the switch member numbers in the stack. These keywords are available only on stacking-capable switches.
<b>show power inline</b> [ <i>interface-id</i>   <b>module</b> <i>switch-number</i> ]	Displays PoE status for a switch or switch stack, for an interface, or for a specific switch in the stack.
<b>show power inline police</b>	Displays the power policing data.

## Additional References

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for PoE

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.
Cisco IOS XE 3.3SE	The <b>four-pair forced</b> keywords were added.



## CHAPTER 12

# Configuring the Cisco eXpandable Power System (XPS) 2200

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This module contains the following sections:

- [Restrictions for Configuring the XPS 2200, on page 177](#)
- [Information About Configuring the XPS 2200, on page 177](#)
- [How to Configure the XPS 2200, on page 181](#)
- [Monitoring and Maintaining the XPS 2200, on page 184](#)
- [Additional References for XPS 2200, on page 184](#)

## Restrictions for Configuring the XPS 2200

- When using the XPS power supplies in the RPS mode for backing up switch power supplies, the smallest power supply in the XPS must be greater than the largest power supply in a switch connected to an XPS port in RPS mode.
- In RPS mode, each XPS power supply can back up one and only one switch power supply, regardless of the size.
- If you remove a power supply from the power stack (from a switch or the XPS), be sure that removing it does not deplete available power enough to cause load shedding.

## Information About Configuring the XPS 2200

### Cisco eXpandable Power System (XPS) 2200 Overview

The Cisco eXpandable Power System (XPS) 2200 is a standalone power system that you can connect to Catalyst switches. The XPS 2200 can provide backup power to connected devices that experience a power supply failure or, in a Catalyst switch power stack, it can supply additional power to the power stack budget. The XPS 2200 power ports and internal power supplies can operate in redundant power supply (RPS) mode or stack power (SP) mode.

Stack-power mode is used only on stacking-capable switches in a power stack. With no XPS, a power stack operates in ring topology with a maximum of four switches in the stack. If you merge two stacks, the total

number of switches cannot exceed four. When an XPS is in the power stack, you can connect up to nine switches in the stack plus the XPS, providing power budgets to power stack members similar to stack-power ring topology operation.

All Catalyst switches connected to an XPS on SP ports are part of the same power stack, and all power from the XPS and the switch is shared across all switches in the stack. Power sharing is the default mode, but the XPS supports the same stack power modes that are supported in a ring topology (strict and nonstrict power-sharing or redundant modes).

When two power supplies are present, the system can operate in mixed mode, where one power supply operates in RPS mode and the other in SP mode. You can configure the ports and power supplies for the way that you plan to use the XPS 2200.

The XPS 2200 has nine power ports that can operate in an RPS role or in an automatic stack power (Auto-SP) role (the default), where mode of operation is determined by the type of switch connected to the port. You can also use the CLI to force the mode to be RPS for stackable switches.

- 
- When a Catalyst switch running the LAN Base image, or a Catalyst (nonstackable) switch is connected to the port, the mode is RPS, and the XPS 2200 acts as a backup if the switch power supply goes down.
- When a Catalyst (stackable) switch running the IP Base image or IP Services image is connected to the port, the mode is SP, which enables the switch to be part of the stack power system.

You configure the XPS through any switch connected to a power port. You can use any XPS port for configuration, and you can configure any port from any switch connected to the XPS. If you enter XPS configuration commands on more than one switch, the last configuration applied takes effect.

Although all XPS configuration is done through a switch, the XPS 2200 also runs its own software. You can upgrade this software through the XPS Service Port.

## XPS 2200 Power Supply Modes

The XPS has two power supplies that can also be in either RPS or SP mode.

In SP mode, all SP ports on the XPS belong to the same power stack. When a power stack includes an XPS, the stack topology is a star topology and consists of up to nine member switches plus the XPS 2200. The XPS power supply or power supplies that are in SP mode are considered in the power budgeting. If both XPS power supplies are in RPS mode, the power stack consists only of the switches connected to XPS ports in SP mode, and the power budget is determined by the power supplies in these switches.

If there is a power supply role mismatch, for example, if an XPS port is configured for RPS and both power supplies are in SP mode, the XPS detects the mismatch, and an error message is sent.

### RPS Mode

When both XPS power supplies are in RPS mode, the XPS can back up two power supply failures for switch power supplies of equal value or less. The smallest power supply in the XPS must be greater than the largest power supply in a switch connected to an XPS port in RPS mode.

If only one supply is in RPS mode, the XPS can back up only one power supply, even when the failed power supply is much smaller. For example, if an XPS 1100 W power supply is in RPS mode and two 350 W switch power supplies fail, the XPS can back up only one of the switch power supplies.



When one XPS power supply in RPS mode is backing up a switch power supply and another switch power supply fails, a message appears that the XPS backup is not available. When the failed power supply comes up, the XPS becomes available to back up other power supplies.

If the XPS is backing up two failed power supplies in a single switch (both XPS power supplies in RPS mode), the XPS is not available to back up other switch power supplies until both of the failed supplies are repaired or replaced.

In mixed mode, with one power supply in RPS mode and one in SP mode, if two power supplies in a single switch fail, because the XPS can back up only one of them, it denies power to both power supplies, and the switch shuts down. This occurs only in mixed power mode.

If a switch is connected to a port configured as RPS, but neither of the power supplies is RPS, the RPS port configuration is rejected and the XPS attempts to add the switch to a power stack. If the switch is not capable of operating in SP mode (is not a stackable switch), the port is disabled.

Ports in RPS mode have a configurable priority. The default priority is based on the XPS port number, with port 1 as the highest priority port. A higher priority port has a higher precedence for backup than a lower priority port. If a switch connected to a higher priority port has a power supply failure while a switch connected to a low priority port is being backed up, the XPS drops power to the low priority port to supply power to the high priority port.

## Stack Power Mode

Stack-power mode is used only on Catalyst switches in a power stack. With no XPS, a power stack operates in ring topology with a maximum of four switches in the stack. When an XPS is in the power stack, you can connect up to nine switches in the stack plus the XPS, providing power budgets to power stack members similar to stack-power ring topology operation.

All Catalyst switches connected to an XPS on SP ports are part of the same power stack, and all power from the XPS and the switches is shared across all switches in the stack. Power sharing is the default mode, but the XPS supports the same stack power modes that are supported in a ring topology (strict and nonstrict power-sharing or redundant modes).

The XPS uses neighbor discovery to create the power stack. When it discovers a Catalyst switch on an unconfigured port, it marks the port as an SP port, and the switch joins the power stack. The XPS notifies the switch, begins the power-budgeting process, and assigns budgets to each switch in the power stack based on their requirements, priorities, current power allocations, and the stack aggregate power capability.

The XPS sends the power budget to each switch. If not enough input power is available to provide every switch with its maximum requested power, power is distributed based on priority. Switches with the highest priority receive required power first, followed by any powered devices that have already been allocated power, in order of their priority. Any remaining power is distributed equally through the stack.

The RPS port priority (1 through 9) does not affect stack power priority. Each switch participating in stack power has its own system priority and a high and low priority for devices connected to its ports. These priorities are used for stack power, as is the case in a ring topology. You configure stack power priority for the system and for high and low-priority ports by using the **power-priority switch**, **power-priority high**, and **power-priority low** commands in switch stack power configuration mode. If a system or set of powered devices are using the default priority, the XPS automatically assigns a priority (1 through 27), with lower MAC addresses receiving higher priorities.

There are four power stack modes: power sharing, strict power sharing, redundant, or strict redundant. You configure the power stack mode by using the **mode {power-sharing | redundant} [strict]** command in power-stack configuration mode. The **power-sharing** or **redundant** configurations affect the power budgeting

aspect of the stack; **strict** or non-strict affects the actions of the PoE application when a budget reduction does not result in load shedding.

- In power sharing modes (strict or nonstrict), the stack power budget is the cumulative capacity of all the power supplies in the stack (minus 30 W reserved power). This is the default.
- In redundant modes (strict or nonstrict), the stack power budget is the total available power (minus 30 W) after the capacity of the largest power supply in the power stack is subtracted. Redundant mode guarantees that no switch or powered device loses power or experiences load sheds if a single power supply fails, but load sheds can occur if more than one power supply fails.
- In strict modes, if a loss of input power results in reduced power budgets but does not result in any hardware load shedding, the XPS automatically begins denying power to low-priority powered devices and then the high-priority powered devices until the amount of allocated power is less than or equal to the amount of available PoE power.
- In nonstrict modes, in the event of a power reduction, the amount of allocated power is allowed to fall under budget.

For example, a system with a total PoE budget (available power) of 400 W can allocate 390 W of the budget (allocated power) to powered devices. The allocated power of a device is the maximum amount of power that the device needs. The actual power consumption (consumed power) for a set of powered devices is usually not equal to the allocated power. In this example, the actual power might be approximately 200 W. If a power loss in the stack reduces the available power to 210 W, this amount is enough to sustain the power being consumed by the powered devices, but less than the worst-case allocated power, which would put the system *under budget*. In strict mode, the stack would immediately deny power to powered devices until the allocated power was 210 W or less. In nonstrict mode, no action is taken, and the state is allowed to persist. In nonstrict mode if the actual power consumption becomes more than 210 W, this triggers a load shed and can result in the loss of power to all powered devices or switches with the lowest priority level.

## Mixed Modes

The XPS 2200 can also operate in mixed mode, where some ports connected to switches are RPS and others are SP. At least one power supply must be an RPS power supply in this configuration. The power supply in the XPS can back up only one switch power supply and the XPS supply must be greater than the largest power supply in a switch connected to an XPS port in RPS mode.

Switches connected to SP ports belong to a single power stack. If the SP switches have a large enough power budget, an SP power supply is not required on the XPS. When an XPS power supply is configured, its power is added to the power pool shared by the power stack.

## XPS 2200 System Defaults

The default role for a port is Auto-SP, where the power mode is determined by the switch connected to the port (RPS for Catalyst running the LAN Base image, or SP for Catalyst switches running the IP Base image or IP Services image).

The default for the XPS power supply A (PS1) is RPS mode. The default for power supply B (PS2) is SP mode.

The default mode for all ports and power supplies is enabled.

On ports configured for RPS, the default priority is the same as the port number.

# How to Configure the XPS 2200

You can configure the XPS from any switch connected to an XPS port. If you enter XPS configuration commands on more than one switch, the last configuration applied takes effect. Only the switch and port name are saved in the switch configuration file.

## Configuring System Names

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>enable</code>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<code>power xps switch-number name {name   serialnumber}</code>	<p><b>Note</b> The <i>switch-number</i> appears only on Catalyst switches and represents the switch number in the data stack, a value from 1 to 9.</p> <p>In a stacked system, the <i>switch-number</i> entered must be the switch number of the active switch.</p> <p>Configures a name for the XPS 2200 system.</p> <ul style="list-style-type: none"> <li>• <i>name</i>—Enter a name for the XPS 2200 system. The name can have up to 20 characters.</li> <li>• <i>serialnumber</i>—Use the serial number of the XPS 2200 as the system name.</li> </ul>
<b>Step 4</b>	<code>power xps switch-number port {name   hostname   serialnumber}</code>	<p>Configures a name for an XPS 2200 port connected to the device.</p> <ul style="list-style-type: none"> <li>• <i>name</i>—Enter a name for the XPS 2200 port.</li> <li>• <i>serialnumber</i>—Use the serial number of the device connected to the port.</li> <li>• <i>hostname</i>—Use the hostname of the device connected to the port.</li> </ul>
<b>Step 5</b>	<code>end</code>	Returns to privileged EXEC mode.
<b>Step 6</b>	<code>show env xps system</code>	Verifies the configured name of the system and ports.

	Command or Action	Purpose
Step 7	copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Configuring XPS Ports

### Procedure

	Command or Action	Purpose
Step 1	enable	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	power xps <i>switch-number</i> port { <i>number</i>   connected} mode {disable   enable}	<p><b>Note</b> The <i>switch-number</i> appears only on Catalyst switches and represents the switch number in the data stack, a value from 1 to 9.</p> <p>Sets the port to be enabled or disabled.</p> <ul style="list-style-type: none"> <li>• <i>number</i>—Enter the XPS 2200 port number. The range is 1 to 9.</li> <li>• <b>connected</b>—Enter this keyword if you do not know the port number to which the switch is connected.</li> <li>• <b>mode disable</b>—Disable (shut down) the XPS port.</li> </ul> <p><b>Note</b> Disabling an XPS port is like removing the cable and appears the same in the <b>show</b> command outputs. If the physical cable is connected, you can still use the <b>enable</b> keyword to enable the port.</p> <ul style="list-style-type: none"> <li>• <b>mode enable</b>—Enable the XPS port. This is the default.</li> </ul>
Step 3	power xps <i>switch-number</i> port { <i>number</i>   connected} role {auto   rps}	<p><b>Note</b> The <i>switch-number</i> represents the switch number in the data stack, a value from 1 to 9.</p> <p>Sets the role of the XPS port.</p> <ul style="list-style-type: none"> <li>• <b>role auto</b>—The port mode is determined by the switch connected to the port. This is the default.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>role RPS</b>—The XPS acts as a back up if the switch power supply fails. At least one RPS power supply must be in RPS mode for this configuration.</li> </ul>
<b>Step 4</b>	<code>power xps switch-number port {number   connected} priority port-priority</code>	<p><b>Note</b> The <i>switch-number</i> represents the switch number in the data stack, a value from 1 to 9.</p> <p>Sets the RPS priority of the port, where higher priority ports take precedence over low priority ports if multiple power supplies fail. This command takes effect only when the port mode is RPS. When the port mode is stack power, you set priority by using the stack power commands.</p> <ul style="list-style-type: none"> <li>• <b>priority port-priority</b>—Set the RPS priority of the port. The range is 1 to 9, with 1 being the highest priority. The default priority is the XPS port number.</li> </ul>
<b>Step 5</b>	<code>show env xps port</code>	Verifies the XPS configuration of the port.
<b>Step 6</b>	<code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring XPS Power Supplies

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>enable</code>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<code>power xps switch-number supply {A   B} mode {rps   sp}</code>	<p><b>Note</b> The <i>switch-number</i> represents the switch number in the data stack, a value from 1 to 9.</p> <p>Sets the XPS power supply mode.</p> <ul style="list-style-type: none"> <li>• <b>supply {A   B}</b>—Select the power supply to configure. Power supply A is on the left (labeled PS1) and power supply B (PS2) is on the right.</li> <li>• <b>mode rps</b>—Set the power supply mode to RPS, to back up connected switches. This</li> </ul>

	Command or Action	Purpose
		<p>is the default setting for power supply A (PS1).</p> <ul style="list-style-type: none"> <li>• <b>mode sp</b>—Set the power supply mode to stack power (SP), to participate in the power stack. This is the default setting for power supply B (PS2).</li> </ul>
<b>Step 3</b>	<b>power xps <i>switch-number</i> supply {A   B} {on   off}</b>	<p><b>Note</b> The <i>switch-number</i> represents the switch number in the data stack, a value from 1 to 9.</p> <p>Sets the XPS power supply to be on or off. The default is for both power supplies to be on.</p>
<b>Step 4</b>	<b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show env xps power</b>	Displays the status of the XPS power supplies.

## Monitoring and Maintaining the XPS 2200

Command	Purpose
<b>show env xps system</b>	Verifies the configured name of the system and ports.
<b>show env xps port</b>	Verifies the XPS configuration of the port.
<b>show env xps power</b>	Displays the status of the XPS power supplies.

## Additional References for XPS 2200

### Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	See the <i>Interface and Hardware Commands</i> section of the <i>Command Reference (Catalyst 3850 Series)</i> .

### Standards and RFCs

Standard/RFC	Title
None	--

**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for XPS 2200

*Table 16: Feature Information for XPS 2200*

Release	Feature
Cisco IOS XE 15.2.(3)E1	XPS 2200 feature is introduced

## Related Documents

Related Topic	Document Title
Configuring Stack Power	Consolidated Platform Configuration Guide, Cisco IOS XE 3.7E and Later (Catalyst 3850 Switches)

## Standards

Standards	Document Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

## MIBs

MIBs	MIBs Link
—	<p>To locate and download MIBs using Cisco IOS XR software, use the Cisco MIB Locator found at the following URL and choose a platform under the Cisco Access Products menu:</p> <p><a href="http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml">http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml</a></p>

## RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

## Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	<a href="http://www.cisco.com/techsupport">http://www.cisco.com/techsupport</a>





## CHAPTER 13

# Configuring EEE

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- [Restrictions for EEE, on page 187](#)
- [How to Configure EEE, on page 188](#)
- [Monitoring EEE, on page 189](#)
- [Configuration Examples for Configuring EEE, on page 190](#)
- [Additional References for EEE, on page 190](#)
- [Feature Information for Configuring EEE, on page 190](#)

## Information About EEE

### EEE Overview

Energy Efficient Ethernet (EEE) is an IEEE 802.3az standard that is designed to reduce power consumption in Ethernet networks during idle periods.

### Default EEE Configuration

EEE is disabled by default.

## Restrictions for EEE

EEE has the following restrictions:

- Changing the EEE configuration resets the interface because the device has to restart Layer 1 autonegotiation.
- You might want to enable the Link Layer Discovery Protocol (LLDP) for devices that require longer wakeup times before they are able to accept data on their receive paths. Doing so enables the device to negotiate for extended system wakeup times from the transmitting link partner.
- EEE is not supported on TenGigabit Ethernet and Multigigabit Ethernet ports.

# How to Configure EEE

You can enable or disable EEE on an interface that is connected to an EEE-capable link partner.

## Enabling or Disabling EEE

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device (config) # <b>interface gigabitethernet 1/0/1</b>	Specifies the interface to be configured, and enter interface configuration mode.
<b>Step 3</b>	<b>power efficient-ethernet auto</b> <b>Example:</b> Device (config-if) # <b>power efficient-ethernet auto</b>	Enables EEE on the specified interface. When EEE is enabled, the device advertises and autonegotiates EEE to its link partner.
<b>Step 4</b>	<b>no power efficient-ethernet auto</b> <b>Example:</b> Device (config-if) # <b>no power efficient-ethernet auto</b>	Disables EEE on the specified interface.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device (config-if) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

# Monitoring EEE

**Table 17: Commands for Displaying EEE Settings**

Command	Purpose
<b>show eee capabilities interface</b> <i>interface-id</i>	Displays EEE capabilities for the specified interface.
<b>show eee status interface</b> <i>interface-id</i>	Displays EEE status information for the specified interface.
<b>show eee counters interface</b> <i>interface-id</i>	Displays EEE counters for the specified interface.

Following are examples of the **show eee** commands

```
Switch#show eee capabilities interface gigabitEthernet2/0/1
Gi2/0/1
EEE(efficient-ethernet): yes (100-Tx and 1000T auto)
Link Partner : yes (100-Tx and 1000T auto)

ASIC/Interface : EEE Capable/EEE Enabled

Switch#show eee status interface gigabitEthernet2/0/1
Gi2/0/1 is up
EEE(efficient-ethernet): Operational
Rx LPI Status : Low Power
Tx LPI Status : Low Power
Wake Error Count : 0

ASIC EEE STATUS
Rx LPI Status : Receiving LPI
Tx LPI Status : Transmitting LPI
Link Fault Status : Link Up
Sync Status : Code group synchronization with data stream intact

Switch#show eee counters interface gigabitEthernet2/0/1

LP Active Tx Time (10us) : 66649648
LP Transitioning Tx : 462
LP Active Rx Time (10us) : 64911682
LP Transitioning Rx : 153
```

## Examples for Catalyst Digital Building Series Switches

```
Switch#show eee capabilities interface gig1/0/1
Gi1/0/1
EEE(efficient-ethernet): yes (100-Tx and 1000T auto)
Link Partner : no

Switch#show eee status int gig1/0/1
Gi1/0/1 is up
EEE(efficient-ethernet): Disagreed
Rx LPI Status : None
Tx LPI Status : None
Wake Error Count : 0
```

## Configuration Examples for Configuring EEE

This example shows how to enable EEE for an interface:

```
Device# configure terminal
Device(config)# interface gigabitethernet 1/0/1
Device(config-if)# power efficient-ethernet auto
```

This example shows how to disable EEE for an interface:

```
Device# configure terminal
Device(config)# interface gigabitethernet 1/0/1
Device(config-if)# no power efficient-ethernet auto
```

## Additional References for EEE

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for Configuring EEE

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.



## PART **V**

### **IPv6**

- [Configuring MLD Snooping, on page 193](#)
- [Configuring IPv6 Unicast Routing, on page 209](#)
- [Implementing IPv6 Multicast, on page 247](#)
- [IPv6 Client IP Address Learning, on page 277](#)
- [Configuring IPv6 WLAN Security, on page 301](#)
- [Configuring IPv6 ACL, on page 321](#)
- [Configuring IPv6 Web Authentication , on page 337](#)
- [IPv6 Client Mobility, on page 347](#)
- [Configuring IPv6 Mobility, on page 353](#)





# CHAPTER 14

## Configuring MLD Snooping

This module contains details of configuring MLD snooping

- [Information About Configuring IPv6 MLD Snooping, on page 193](#)
- [How to Configure IPv6 MLD Snooping, on page 197](#)
- [Displaying MLD Snooping Information, on page 205](#)
- [Configuration Examples for Configuring MLD Snooping, on page 206](#)

## Information About Configuring IPv6 MLD Snooping



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**Note** To use IPv6 MLD Snooping, the switch must be running the LAN Base image.

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You can use Multicast Listener Discovery (MLD) snooping to enable efficient distribution of IP Version 6 (IPv6) multicast data to clients and routers in a switched network on the switch. Unless otherwise noted, the term switch refers to a standalone switch and to a switch stack.



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**Note** Stacking is supported only on Catalyst 2960-X switches running the LAN base image.

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**Note** To use IPv6, you must configure the dual IPv4 and IPv6 Switch Database Management (SDM) template on the switch.

On switches running the LAN Base feature set, the routing template is not supported.

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**Note** For complete syntax and usage information for the commands used in this chapter, see the command reference for this release or the Cisco IOS documentation referenced in the procedures.

---

## Understanding MLD Snooping

In IP Version 4 (IPv4), Layer 2 switches can use Internet Group Management Protocol (IGMP) snooping to limit the flooding of multicast traffic by dynamically configuring Layer 2 interfaces so that multicast traffic is forwarded to only those interfaces associated with IP multicast devices. In IPv6, MLD snooping performs a similar function. With MLD snooping, IPv6 multicast data is selectively forwarded to a list of ports that want to receive the data, instead of being flooded to all ports in a VLAN. This list is constructed by snooping IPv6 multicast control packets.

MLD is a protocol used by IPv6 multicast routers to discover the presence of multicast listeners (nodes wishing to receive IPv6 multicast packets) on the links that are directly attached to the routers and to discover which multicast packets are of interest to neighboring nodes. MLD is derived from IGMP; MLD Version 1 (MLDv1) is equivalent to IGMPv2, and MLD Version 2 (MLDv2) is equivalent to IGMPv3. MLD is a subprotocol of Internet Control Message Protocol Version 6 (ICMPv6), and MLD messages are a subset of ICMPv6 messages, identified in IPv6 packets by a preceding Next Header value of 58.

The switch supports two versions of MLD snooping:

- MLDv1 snooping detects MLDv1 control packets and sets up traffic bridging based on IPv6 destination multicast addresses.
- MLDv2 basic snooping (MBSS) uses MLDv2 control packets to set up traffic forwarding based on IPv6 destination multicast addresses.

The switch can snoop on both MLDv1 and MLDv2 protocol packets and bridge IPv6 multicast data based on destination IPv6 multicast addresses.




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**Note** The switch does not support MLDv2 enhanced snooping, which sets up IPv6 source and destination multicast address-based forwarding.

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MLD snooping can be enabled or disabled globally or per VLAN. When MLD snooping is enabled, a per-VLAN IPv6 multicast address table is constructed in software and hardware. The switch then performs IPv6 multicast-address based bridging in hardware.

According to IPv6 multicast standards, the switch derives the MAC multicast address by performing a logical-OR of the four low-order octets of the switch MAC address with the MAC address of 33:33:00:00:00:00. For example, the IPv6 MAC address of FF02:DEAD:BEEF:1:3 maps to the Ethernet MAC address of 33:33:00:01:00:03.

A multicast packet is unmatched when the destination IPv6 address does not match the destination MAC address. The switch forwards the unmatched packet in hardware based the MAC address table. If the destination MAC address is not in the MAC address table, the switch floods the packet to all ports in the same VLAN as the receiving port.

## MLD Messages

MLDv1 supports three types of messages:

- Listener Queries are the equivalent of IGMPv2 queries and are either General Queries or Multicast-Address-Specific Queries (MASQs).
- Multicast Listener Reports are the equivalent of IGMPv2 reports
- Multicast Listener Done messages are the equivalent of IGMPv2 leave messages.



MLDv2 supports MLDv2 queries and reports, as well as MLDv1 Report and Done messages.

Message timers and state transitions resulting from messages being sent or received are the same as those of IGMPv2 messages. MLD messages that do not have valid link-local IPv6 source addresses are ignored by MLD routers and switches.

## MLD Queries

The switch sends out MLD queries, constructs an IPv6 multicast address database, and generates MLD group-specific and MLD group-and-source-specific queries in response to MLD Done messages. The switch also supports report suppression, report proxying, Immediate-Leave functionality, and static IPv6 multicast group address configuration.

When MLD snooping is disabled, all MLD queries are flooded in the ingress VLAN.

When MLD snooping is enabled, received MLD queries are flooded in the ingress VLAN, and a copy of the query is sent to the CPU for processing. From the received query, MLD snooping builds the IPv6 multicast address database. It detects multicast router ports, maintains timers, sets report response time, learns the querier IP source address for the VLAN, learns the querier port in the VLAN, and maintains multicast-address aging.



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**Note** When the IPv6 multicast router is a Catalyst 6500 switch and you are using extended VLANs (in the range 1006 to 4094), IPv6 MLD snooping must be enabled on the extended VLAN on the Catalyst 6500 switch in order for the Catalyst 2960, 2960-S, 2960-C, 2960-X or 2960-CX switch to receive queries on the VLAN. For normal-range VLANs (1 to 1005), it is not necessary to enable IPv6 MLD snooping on the VLAN on the Catalyst 6500 switch.

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When a group exists in the MLD snooping database, the switch responds to a group-specific query by sending an MLDv1 report. When the group is unknown, the group-specific query is flooded to the ingress VLAN.

When a host wants to leave a multicast group, it can send out an MLD Done message (equivalent to IGMP Leave message). When the switch receives an MLDv1 Done message, if Immediate-Leave is not enabled, the switch sends an MASQ to the port from which the message was received to determine if other devices connected to the port should remain in the multicast group.

## Multicast Client Aging Robustness

You can configure port membership removal from addresses based on the number of queries. A port is removed from membership to an address only when there are no reports to the address on the port for the configured number of queries. The default number is 2.

## Multicast Router Discovery

Like IGMP snooping, MLD snooping performs multicast router discovery, with these characteristics:

- Ports configured by a user never age out.
- Dynamic port learning results from MLDv1 snooping queries and IPv6 PIMv2 packets.
- If there are multiple routers on the same Layer 2 interface, MLD snooping tracks a single multicast router on the port (the router that most recently sent a router control packet).
- Dynamic multicast router port aging is based on a default timer of 5 minutes; the multicast router is deleted from the router port list if no control packet is received on the port for 5 minutes.

- IPv6 multicast router discovery only takes place when MLD snooping is enabled on the switch.
- Received IPv6 multicast router control packets are always flooded to the ingress VLAN, whether or not MLD snooping is enabled on the switch.
- After the discovery of the first IPv6 multicast router port, unknown IPv6 multicast data is forwarded only to the discovered router ports (before that time, all IPv6 multicast data is flooded to the ingress VLAN).

## MLD Reports

The processing of MLDv1 join messages is essentially the same as with IGMPv2. When no IPv6 multicast routers are detected in a VLAN, reports are not processed or forwarded from the switch. When IPv6 multicast routers are detected and an MLDv1 report is received, an IPv6 multicast group address is entered in the VLAN MLD database. Then all IPv6 multicast traffic to the group within the VLAN is forwarded using this address. When MLD snooping is disabled, reports are flooded in the ingress VLAN.

When MLD snooping is enabled, MLD report suppression, called listener message suppression, is automatically enabled. With report suppression, the switch forwards the first MLDv1 report received by a group to IPv6 multicast routers; subsequent reports for the group are not sent to the routers. When MLD snooping is disabled, report suppression is disabled, and all MLDv1 reports are flooded to the ingress VLAN.

The switch also supports MLDv1 proxy reporting. When an MLDv1 MASQ is received, the switch responds with MLDv1 reports for the address on which the query arrived if the group exists in the switch on another port and if the port on which the query arrived is not the last member port for the address.

## MLD Done Messages and Immediate-Leave

When the Immediate-Leave feature is enabled and a host sends an MLDv1 Done message (equivalent to an IGMP leave message), the port on which the Done message was received is immediately deleted from the group. You enable Immediate-Leave on VLANs and (as with IGMP snooping), you should only use the feature on VLANs where a single host is connected to the port. If the port was the last member of a group, the group is also deleted, and the leave information is forwarded to the detected IPv6 multicast routers.

When Immediate Leave is not enabled in a VLAN (which would be the case when there are multiple clients for a group on the same port) and a Done message is received on a port, an MASQ is generated on that port. The user can control when a port membership is removed for an existing address in terms of the number of MASQs. A port is removed from membership to an address when there are no MLDv1 reports to the address on the port for the configured number of queries.

The number of MASQs generated is configured by using the **ipv6 mld snooping last-listener-query count** global configuration command. The default number is 2.

The MASQ is sent to the IPv6 multicast address for which the Done message was sent. If there are no reports sent to the IPv6 multicast address specified in the MASQ during the switch maximum response time, the port on which the MASQ was sent is deleted from the IPv6 multicast address database. The maximum response time is the time configured by using the **ipv6 mld snooping last-listener-query-interval** global configuration command. If the deleted port is the last member of the multicast address, the multicast address is also deleted, and the switch sends the address leave information to all detected multicast routers.

When Immediate Leave is not enabled and a port receives an MLD Done message, the switch generates MASQs on the port and sends them to the IPv6 multicast address for which the Done message was sent. You can optionally configure the number of MASQs that are sent and the length of time the switch waits for a response before deleting the port from the multicast group.

When you enable MLDv1 Immediate Leave, the switch immediately removes a port from a multicast group when it detects an MLD Done message on that port. You should only use the Immediate-Leave feature when there is a single receiver present on every port in the VLAN. When there are multiple clients for a multicast group on the same port, you should not enable Immediate-Leave in a VLAN.

## Topology Change Notification Processing

When topology change notification (TCN) solicitation is enabled by using the **ipv6 mld snooping tcn query solicit** global configuration command, MLDv1 snooping sets the VLAN to flood all IPv6 multicast traffic with a configured number of MLDv1 queries before it begins sending multicast data only to selected ports. You set this value by using the **ipv6 mld snooping tcn flood query count** global configuration command. The default is to send two queries. The switch also generates MLDv1 global Done messages with valid link-local IPv6 source addresses when the switch becomes the STP root in the VLAN or when it is configured by the user. This is same as done in IGMP snooping.

# How to Configure IPv6 MLD Snooping

## Default MLD Snooping Configuration

*Table 18: Default MLD Snooping Configuration*

Feature	Default Setting
MLD snooping (Global)	Disabled.
MLD snooping (per VLAN)	Enabled. MLD snooping must be globally enabled for VLAN MLD snooping to take place.
IPv6 Multicast addresses	None configured.
IPv6 Multicast router ports	None configured.
MLD snooping Immediate Leave	Disabled.
MLD snooping robustness variable	Global: 2; Per VLAN: 0. <b>Note</b> The VLAN value overrides the global setting. When the VLAN value is 0, the VLAN uses the global count.
Last listener query count	Global: 2; Per VLAN: 0. <b>Note</b> The VLAN value overrides the global setting. When the VLAN value is 0, the VLAN uses the global count.
Last listener query interval	Global: 1000 (1 second); VLAN: 0. <b>Note</b> The VLAN value overrides the global setting. When the VLAN value is 0, the VLAN uses the global interval.

Feature	Default Setting
TCN query solicit	Disabled.
TCN query count	2.
MLD listener suppression	Disabled.

## MLD Snooping Configuration Guidelines

When configuring MLD snooping, consider these guidelines:

- You can configure MLD snooping characteristics at any time, but you must globally enable MLD snooping by using the **ipv6 mld snooping** global configuration command for the configuration to take effect.
- When the IPv6 multicast router is a Catalyst 6500 switch and you are using extended VLANs (in the range 1006 to 4094), IPv6 MLD snooping must be enabled on the extended VLAN on the Catalyst 6500 switch in order for the switch to receive queries on the VLAN. For normal-range VLANs (1 to 1005), it is not necessary to enable IPv6 MLD snooping on the VLAN on the Catalyst 6500 switch.
- MLD snooping and IGMP snooping act independently of each other. You can enable both features at the same time on the switch.
- The maximum number of multicast entries allowed on the switch or switch stack is determined by the configured SDM template.
- The maximum number of address entries allowed for the switch or switch stack is 4000.

## Enabling or Disabling MLD Snooping on the Switch

By default, IPv6 MLD snooping is globally disabled on the switch and enabled on all VLANs. When MLD snooping is globally disabled, it is also disabled on all VLANs. When you globally enable MLD snooping, the VLAN configuration overrides the global configuration. That is, MLD snooping is enabled only on VLAN interfaces in the default state (enabled).

You can enable and disable MLD snooping on a per-VLAN basis or for a range of VLANs, but if you globally disable MLD snooping, it is disabled in all VLANs. If global snooping is enabled, you can enable or disable VLAN snooping.

To globally enable MLD snooping on the switch, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 3</b>	<b>ipv6 mld snooping</b> <b>Example:</b> Device(config)# <code>ipv6 mld snooping</code>	Enables MLD snooping on the switch.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device(config)# <code>copy running-config startup-config</code>	(Optional) Save your entries in the configuration file.
<b>Step 6</b>	<b>reload</b> <b>Example:</b> Device(config)# <code>reload</code>	Reload the operating system.

## Enabling or Disabling MLD Snooping on a VLAN

To enable MLD snooping on a VLAN, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>ipv6 mld snooping</b> <b>Example:</b> <pre>Device(config)# ipv6 mld snooping</pre>	Enables MLD snooping on the switch.
<b>Step 4</b>	<b>ipv6 mld snooping vlan <i>vlan-id</i></b> <b>Example:</b> <pre>Device(config)# ipv6 mld snooping vlan 1</pre>	Enables MLD snooping on the VLAN. The VLAN ID range is 1 to 1001 and 1006 to 4094. <b>Note</b> MLD snooping must be globally enabled for VLAN snooping to be enabled.
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# ipv6 mld snooping vlan 1</pre>	Returns to privileged EXEC mode.

## Configuring a Static Multicast Group

Hosts or Layer 2 ports normally join multicast groups dynamically, but you can also statically configure an IPv6 multicast address and member ports for a VLAN.

To add a Layer 2 port as a member of a multicast group, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 mld snooping vlan <i>vlan-id</i> static <i>ipv6_multicast_address</i> interface <i>interface-id</i></b> <b>Example:</b> <pre>Device(config)# ipv6 mld snooping vlan 1 static 3333.0000.1111 interface</pre>	Configures a multicast group with a Layer 2 port as a member of a multicast group: <ul style="list-style-type: none"> <li>• <i>vlan-id</i> is the multicast group VLAN ID. The VLAN ID range is 1 to 1001 and 1006 to 4094.</li> </ul>

	Command or Action	Purpose
	<code>gigabitethernet 0/1</code>	<ul style="list-style-type: none"> <li>• <i>ipv6_multicast_address</i> is the 128-bit group IPv6 address. The address must be in the form specified in RFC 2373.</li> <li>• <i>interface-id</i> is the member port. It can be a physical interface or a port channel (1 to 48).</li> </ul>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>show ipv6 mld snooping address</b></li> <li>• <b>show ipv6 mld snooping address vlan vlan-id</b></li> </ul> <b>Example:</b> Device# <b>show ipv6 mld snooping address</b> OR Device# <b>show ipv6 mld snooping vlan 1</b>	Verifies the static member port and the IPv6 address.

## Configuring a Multicast Router Port



**Note** Static connections to multicast routers are supported only on switch ports.

To add a multicast router port to a VLAN, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>ipv6 mld snooping vlan <i>vlan-id</i> mrouter interface <i>interface-id</i></b>  <b>Example:</b> <pre>Device(config)# ipv6 mld snooping vlan 1 mrouter interface gigabitethernet 0/2</pre>	Specifies the multicast router VLAN ID, and specify the interface to the multicast router. <ul style="list-style-type: none"> <li>• The VLAN ID range is 1 to 1001 and 1006 to 4094.</li> <li>• The interface can be a physical interface or a port channel. The port-channel range is 1 to 48.</li> </ul>
<b>Step 4</b>	<b>end</b>  <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show ipv6 mld snooping mrouter [ vlan <i>vlan-id</i> ]</b>  <b>Example:</b> <pre>Device# show ipv6 mld snooping mrouter vlan 1</pre>	Verifies that IPv6 MLD snooping is enabled on the VLAN interface.

## Enabling MLD Immediate Leave

To enable MLDv1 immediate leave, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode.  Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 mld snooping vlan <i>vlan-id</i> immediate-leave</b>  <b>Example:</b> <pre>Device(config)# ipv6 mld snooping vlan 1 immediate-leave</pre>	Enables MLD Immediate Leave on the VLAN interface.



	Command or Action	Purpose
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show ipv6 mld snooping vlan</b> <i>vlan-id</i> <b>Example:</b> Device# <b>show ipv6 mld snooping vlan 1</b>	Verifies that Immediate Leave is enabled on the VLAN interface.

## Configuring MLD Snooping Queries

To configure MLD snooping query characteristics for the switch or for a VLAN, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 mld snooping robustness-variable</b> <i>value</i> <b>Example:</b> Device(config)# <b>ipv6 mld snooping robustness-variable 3</b>	(Optional) Sets the number of queries that are sent before switch will deletes a listener (port) that does not respond to a general query. The range is 1 to 3; the default is 2.
<b>Step 4</b>	<b>ipv6 mld snooping vlan</b> <i>vlan-id</i> <b>robustness-variable</b> <i>value</i> <b>Example:</b> Device(config)# <b>ipv6 mld snooping vlan 1 robustness-variable 3</b>	(Optional) Sets the robustness variable on a VLAN basis, which determines the number of general queries that MLD snooping sends before aging out a multicast address when there is no MLD report response. The range is 1 to 3; the default is 0. When set to 0, the number used is the global robustness variable value.
<b>Step 5</b>	<b>ipv6 mld snooping last-listener-query-count</b> <i>count</i> <b>Example:</b>	(Optional) Sets the number of MASQs that the switch sends before aging out an MLD client. The range is 1 to 7; the default is 2. The queries are sent 1 second apart.

	Command or Action	Purpose
	Device (config)# <b>ipv6 mld snooping last-listener-query-count 7</b>	
<b>Step 6</b>	<b>ipv6 mld snooping vlan <i>vlan-id</i> last-listener-query-count <i>count</i></b>  <b>Example:</b> Device (config)# <b>ipv6 mld snooping vlan 1 last-listener-query-count 7</b>	(Optional) Sets the last-listener query count on a VLAN basis. This value overrides the value configured globally. The range is 1 to 7; the default is 0. When set to 0, the global count value is used. Queries are sent 1 second apart.
<b>Step 7</b>	<b>ipv6 mld snooping last-listener-query-interval <i>interval</i></b>  <b>Example:</b> Device (config)# <b>ipv6 mld snooping last-listener-query-interval 2000</b>	(Optional) Sets the maximum response time that the switch waits after sending out a MASQ before deleting a port from the multicast group. The range is 100 to 32,768 thousands of a second. The default is 1000 (1 second).
<b>Step 8</b>	<b>ipv6 mld snooping vlan <i>vlan-id</i> last-listener-query-interval <i>interval</i></b>  <b>Example:</b> Device (config)# <b>ipv6 mld snooping vlan 1 last-listener-query-interval 2000</b>	(Optional) Sets the last-listener query interval on a VLAN basis. This value overrides the value configured globally. The range is 0 to 32,768 thousands of a second. The default is 0. When set to 0, the global last-listener query interval is used.
<b>Step 9</b>	<b>ipv6 mld snooping tcn query solicit</b>  <b>Example:</b> Device (config)# <b>ipv6 mld snooping tcn query solicit</b>	(Optional) Enables topology change notification (TCN) solicitation, which means that VLANs flood all IPv6 multicast traffic for the configured number of queries before sending multicast data to only those ports requesting to receive it. The default is for TCN to be disabled.
<b>Step 10</b>	<b>ipv6 mld snooping tcn flood query count <i>count</i></b>  <b>Example:</b> Device (config)# <b>ipv6 mld snooping tcn flood query count 5</b>	(Optional) When TCN is enabled, specifies the number of TCN queries to be sent. The range is from 1 to 10; the default is 2.
<b>Step 11</b>	<b>end</b>	Returns to privileged EXEC mode.
<b>Step 12</b>	<b>show ipv6 mld snooping querier [ vlan <i>vlan-id</i>]</b>  <b>Example:</b> Device (config)# <b>show ipv6 mld snooping querier vlan 1</b>	(Optional) Verifies that the MLD snooping querier information for the switch or for the VLAN.

## Disabling MLD Listener Message Suppression

MLD snooping listener message suppression is enabled by default. When it is enabled, the switch forwards only one MLD report per multicast router query. When message suppression is disabled, multiple MLD reports could be forwarded to the multicast routers.

To disable MLD listener message suppression, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enter global configuration mode.
<b>Step 3</b>	<b>no ipv6 mld snooping listener-message-suppression</b> <b>Example:</b>  Device(config)# <b>no ipv6 mld snooping listener-message-suppression</b>	Disable MLD message suppression.
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Return to privileged EXEC mode.
<b>Step 5</b>	<b>show ipv6 mld snooping</b> <b>Example:</b>  Device# <b>show ipv6 mld snooping</b>	Verify that IPv6 MLD snooping report suppression is disabled.

## Displaying MLD Snooping Information

You can display MLD snooping information for dynamically learned and statically configured router ports and VLAN interfaces. You can also display IPv6 group address multicast entries for a VLAN configured for MLD snooping.

Table 19: Commands for Displaying MLD Snooping Information

Command	Purpose
<b>show ipv6 mld snooping</b> [ <b>vlan</b> <i>vlan-id</i> ]	Displays the MLD snooping configuration information for all VLANs on the switch or for a specified VLAN.  (Optional) Enter <b>vlan</b> <i>vlan-id</i> to display information for a single VLAN. The VLAN ID range is 1 to 1001 and 1006 to 4094.
<b>show ipv6 mld snooping mrouter</b> [ <b>vlan</b> <i>vlan-id</i> ]	Displays information on dynamically learned and manually configured multicast router interfaces. When you enable MLD snooping, the switch automatically learns the interface to which a multicast router is connected. These are dynamically learned interfaces.  (Optional) Enters <b>vlan</b> <i>vlan-id</i> to display information for a single VLAN. The VLAN ID range is 1 to 1001 and 1006 to 4094.
<b>show ipv6 mld snooping querier</b> [ <b>vlan</b> <i>vlan-id</i> ]	Displays information about the IPv6 address and incoming port for the most-recently received MLD query messages in the VLAN.  (Optional) Enters <b>vlan</b> <i>vlan-id</i> to display information for a single VLAN. The VLAN ID range is 1 to 1001 and 1006 to 4094.
<b>show ipv6 mld snooping address</b> [ <b>vlan</b> <i>vlan-id</i> ] [ <b>count</b>   <b>dynamic</b>   <b>user</b> ]	Displays all IPv6 multicast address information or specific IPv6 multicast address information for the switch or a VLAN. <ul style="list-style-type: none"> <li>• Enters <b>count</b> to show the group count on the switch or in a VLAN.</li> <li>• Enters <b>dynamic</b> to display MLD snooping learned group information for the switch or for a VLAN.</li> <li>• Enters <b>user</b> to display MLD snooping user-configured group information for the switch or for a VLAN.</li> </ul>
<b>show ipv6 mld snooping address</b> <b>vlan</b> <i>vlan-id</i> [ <i>ipv6-multicast-address</i> ]	Displays MLD snooping for the specified VLAN and IPv6 multicast address.

## Configuration Examples for Configuring MLD Snooping

### Configuring a Static Multicast Group: Example

This example shows how to statically configure an IPv6 multicast group:

```
Device# configure terminal
Device(config)# ipv6 mld snooping vlan 2 static 3333.0000.1111 interface gigabitethernet1/0/1
Device(config)# end
```

## Configuring a Multicast Router Port: Example

This example shows how to add a multicast router port to VLAN 200:

```
Device# configure terminal
Device(config)# ipv6 mld snooping vlan 200 mrouter interface gigabitethernet
0/2
Device(config)# exit
```

## Enabling MLD Immediate Leave: Example

This example shows how to enable MLD Immediate Leave on VLAN 130:

```
Device# configure terminal
Device(config)# ipv6 mld snooping vlan 130 immediate-leave
Device(config)# exit
```

## Configuring MLD Snooping Queries: Example

This example shows how to set the MLD snooping global robustness variable to 3:

```
Device# configure terminal
Device(config)# ipv6 mld snooping robustness-variable 3
Device(config)# exit
```

This example shows how to set the MLD snooping last-listener query count for a VLAN to 3:

```
Device# configure terminal
Device(config)# ipv6 mld snooping vlan 200 last-listener-query-count 3
Device(config)# exit
```

This example shows how to set the MLD snooping last-listener query interval (maximum response time) to 2000 (2 seconds):

```
Device# configure terminal
Device(config)# ipv6 mld snooping last-listener-query-interval 2000
Device(config)# exit
```





## CHAPTER 15

# Configuring IPv6 Unicast Routing

- [Information About Configuring IPv6 Unicast Routing, on page 209](#)
- [Configuring DHCP for IPv6 Address Assignment, on page 237](#)
- [Configuration Examples for IPv6 Unicast Routing, on page 241](#)

## Information About Configuring IPv6 Unicast Routing

This chapter describes how to configure IPv6 unicast routing on the switch.



**Note** To use all IPv6 features in this chapter, the switch or stack master must be running the IP services feature set. Switches running the IP base feature set support IPv6 static routing, RIP for IPv6, and OSPF. Switches running the LAN base feature set support only IPv6 host functionality.

## Understanding IPv6

IPv4 users can move to IPv6 and receive services such as end-to-end security, quality of service (QoS), and globally unique addresses. The IPv6 address space reduces the need for private addresses and Network Address Translation (NAT) processing by border routers at network edges.

For information about how Cisco Systems implements IPv6, go to:

[http://www.cisco.com/en/US/products/ps6553/products\\_ios\\_technology\\_home.html](http://www.cisco.com/en/US/products/ps6553/products_ios_technology_home.html)

For information about IPv6 and other features in this chapter

- See the *Cisco IOS IPv6 Configuration Library*.
- Use the Search field on Cisco.com to locate the Cisco IOS software documentation. For example, if you want information about static routes, you can enter *Implementing Static Routes for IPv6* in the search field to learn about static routes.

## IPv6 Addresses

The switch supports only IPv6 unicast addresses. It does not support site-local unicast addresses, or anycast addresses.

The IPv6 128-bit addresses are represented as a series of eight 16-bit hexadecimal fields separated by colons in the format: n:n:n:n:n:n:n:n. This is an example of an IPv6 address:

```
2031:0000:130F:0000:0000:09C0:080F:130B
```

For easier implementation, leading zeros in each field are optional. This is the same address without leading zeros:

```
2031:0:130F:0:0:9C0:80F:130B
```

You can also use two colons (::) to represent successive hexadecimal fields of zeros, but you can use this short version only once in each address:

```
2031:0:130F::09C0:080F:130B
```

For more information about IPv6 address formats, address types, and the IPv6 packet header, see the [http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/ipv6\\_basic/configuration/xr-3e/ip6b-xe-3e-book.html](http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/ipv6_basic/configuration/xr-3e/ip6b-xe-3e-book.html) of *Cisco IOS IPv6 Configuration Library* on Cisco.com.

In the “Information About Implementing Basic Connectivity for IPv6” chapter, these sections apply to the switch:

- IPv6 Address Formats
- IPv6 Address Type: Unicast
- IPv6 Address Type: Multicast
- IPv6 Address Output Display
- Simplified IPv6 Packet Header

## Supported IPv6 Unicast Routing Features

These sections describe the IPv6 protocol features supported by the switch:

The switch provides IPv6 routing capability over Routing Information Protocol (RIP) for IPv6, and Open Shortest Path First (OSPF) Version 3 Protocol. It supports up to 16 equal-cost routes and can simultaneously forward IPv4 and IPv6 frames at line rate.

### 128-Bit Wide Unicast Addresses

The switch supports aggregatable global unicast addresses and link-local unicast addresses. It does not support site-local unicast addresses.

- Aggregatable global unicast addresses are IPv6 addresses from the aggregatable global unicast prefix. The address structure enables strict aggregation of routing prefixes and limits the number of routing table entries in the global routing table. These addresses are used on links that are aggregated through organizations and eventually to the Internet service provider.

These addresses are defined by a global routing prefix, a subnet ID, and an interface ID. Current global unicast address allocation uses the range of addresses that start with binary value 001 (2000::/3). Addresses with a prefix of 2000::/3(001) through E000::/3(111) must have 64-bit interface identifiers in the extended unique identifier (EUI)-64 format.

- Link local unicast addresses can be automatically configured on any interface by using the link-local prefix FE80::/10(1111 1110 10) and the interface identifier in the modified EUI format. Link-local addresses are used in the neighbor discovery protocol (NDP) and the stateless autoconfiguration process.



Nodes on a local link use link-local addresses and do not require globally unique addresses to communicate. IPv6 routers do not forward packets with link-local source or destination addresses to other links.

For more information, see the section about IPv6 unicast addresses in the “Implementing IPv6 Addressing and Basic Connectivity” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## DNS for IPv6

IPv6 supports Domain Name System (DNS) record types in the DNS name-to-address and address-to-name lookup processes. The DNS AAAA resource record types support IPv6 addresses and are equivalent to an A address record in IPv4. The switch supports DNS resolution for IPv4 and IPv6.

## Path MTU Discovery for IPv6 Unicast

The switch supports advertising the system maximum transmission unit (MTU) to IPv6 nodes and path MTU discovery. Path MTU discovery allows a host to dynamically discover and adjust to differences in the MTU size of every link along a given data path. In IPv6, if a link along the path is not large enough to accommodate the packet size, the source of the packet handles the fragmentation.

## ICMPv6

The Internet Control Message Protocol (ICMP) in IPv6 generates error messages, such as ICMP destination unreachable messages, to report errors during processing and other diagnostic functions. In IPv6, ICMP packets are also used in the neighbor discovery protocol and path MTU discovery.

## Neighbor Discovery

The switch supports NDP for IPv6, a protocol running on top of ICMPv6, and static neighbor entries for IPv6 stations that do not support NDP. The IPv6 neighbor discovery process uses ICMP messages and solicited-node multicast addresses to determine the link-layer address of a neighbor on the same network (local link), to verify the reachability of the neighbor, and to keep track of neighboring routers.

The switch supports ICMPv6 redirect for routes with mask lengths less than 64 bits. ICMP redirect is not supported for host routes or for summarized routes with mask lengths greater than 64 bits.

Neighbor discovery throttling ensures that the switch CPU is not unnecessarily burdened while it is in the process of obtaining the next hop forwarding information to route an IPv6 packet. The switch drops any additional IPv6 packets whose next hop is the same neighbor that the switch is actively trying to resolve. This drop avoids further load on the CPU.

## Default Router Preference

The switch supports IPv6 default router preference (DRP), an extension in router advertisement messages. DRP improves the ability of a host to select an appropriate router, especially when the host is multihomed and the routers are on different links. The switch does not support the Route Information Option in RFC 4191.

An IPv6 host maintains a default router list from which it selects a router for traffic to offlink destinations. The selected router for a destination is then cached in the destination cache. NDP for IPv6 specifies that routers that are reachable or probably reachable are preferred over routers whose reachability is unknown or suspect. For reachable or probably reachable routers, NDP can either select the same router every time or cycle through the router list. By using DRP, you can configure an IPv6 host to prefer one router over another, provided both are reachable or probably reachable.

For configuring DRP for IPv6, see the *Configuring Default Router Preference* section.

For more information about DRP for IPv6, see the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## IPv6 Stateless Autoconfiguration and Duplicate Address Detection

The switch uses stateless autoconfiguration to manage link, subnet, and site addressing changes, such as management of host and mobile IP addresses. A host autonomously configures its own link-local address, and booting nodes send router solicitations to request router advertisements for configuring interfaces.

Beginning from Cisco IOS XE Gibraltar 16.11.1, an autoconfigured IPv6 address will contain interface identifiers that are not part of the reserved interface identifiers range specified in RFC5453.

For more information about autoconfiguration and duplicate address detection, see the “Implementing IPv6 Addressing and Basic Connectivity” chapter of *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## IPv6 Applications

The switch has IPv6 support for these applications:

- Ping, traceroute, Telnet, and TFTP
- Secure Shell (SSH) over an IPv6 transport
- HTTP server access over IPv6 transport
- DNS resolver for AAAA over IPv4 transport
- Cisco Discovery Protocol (CDP) support for IPv6 addresses

For more information about managing these applications, see the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## DHCP for IPv6 Address Assignment

DHCPv6 enables DHCP servers to pass configuration parameters, such as IPv6 network addresses, to IPv6 clients. The address assignment feature manages non-duplicate address assignment in the correct prefix based on the network where the host is connected. Assigned addresses can be from one or multiple prefix pools. Additional options, such as default domain and DNS name-server address, can be passed back to the client. Address pools can be assigned for use on a specific interface, on multiple interfaces, or the server can automatically find the appropriate pool.

For configuring DHCP for IPv6, see the *Configuring DHCP for IPv6 Address Assignment* section.

For more information about configuring the DHCPv6 client, server, or relay agent functions, see the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## Static Routes for IPv6

Static routes are manually configured and define an explicit route between two networking devices. Static routes are useful for smaller networks with only one path to an outside network or to provide security for certain types of traffic in a larger network.

Configuring Static Routing for IPv6 (CLI)

For configuring static routes for IPv6, see the *Configuring Static Routing for IPv6* section.

For more information about static routes, see the “Implementing Static Routes for IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## Policy-Based Routing for IPv6

Policy-based routing (PBR) gives you a flexible means of routing packets by allowing you to configure a defined policy for traffic flows, which lessens reliance on routes derived from routing protocols. Therefore, PBR gives you more control over routing by extending and complementing the existing mechanisms provided by routing protocols. PBR allows you to set the IPv6 precedence. For a simple policy, you can use any one of these tasks; for a complex policy, you can use all of them. It also allows you to specify a path for certain traffic, such as priority traffic over a high-cost link.

PBR for IPv6 may be applied to both forwarded and originated IPv6 packets. For forwarded packets, PBR for IPv6 will be implemented as an IPv6 input interface feature, supported in the following forwarding paths:

- Process
- Cisco Express Forwarding (formerly known as CEF)
- Distributed Cisco Express Forwarding

Policies can be based on the IPv6 address, port numbers, protocols, or packet size.

PBR allows you to perform the following tasks:

- Classify traffic based on extended access list criteria. Access lists, then, establish the match criteria.
- Set IPv6 precedence bits, giving the network the ability to enable differentiated classes of service.
- Route packets to specific traffic-engineered paths; you might need to route them to allow a specific quality of service (QoS) through the network.

PBR allows you to classify and mark packets at the edge of the network. PBR marks a packet by setting precedence value. The precedence value can be used directly by devices in the network core to apply the appropriate QoS to a packet, which keeps packet classification at your network edge.

For enabling PBR for IPv6, see the *Enabling Local PBR for IPv6* section.

For enabling IPv6 PBR for an interface, see the *Enabling IPv6 PBR on an Interface* section.

## RIP for IPv6

Routing Information Protocol (RIP) for IPv6 is a distance-vector protocol that uses hop count as a routing metric. It includes support for IPv6 addresses and prefixes and the all-RIP-routers multicast group address FF02::9 as the destination address for RIP update messages.

For configuring RIP for IPv6, see the *Configuring RIP for IPv6* section.

For more information about RIP for IPv6, see the “Implementing RIP for IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## OSPF for IPv6

The switch running the IP Base feature set supports Open Shortest Path First (OSPF) for IPv6, a link-state protocol for IP. For more information, see *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## Configuring HSRP for IPv6

HSRP provides routing redundancy for routing IPv6 traffic not dependent on the availability of any single router. IPv6 hosts learn of available routers through IPv6 neighbor discovery router advertisement messages. These messages are multicast periodically or are solicited by hosts.

An HSRP IPv6 group has a virtual MAC address that is derived from the HSRP group number and a virtual IPv6 link-local address that is, by default, derived from the HSRP virtual MAC address. Periodic messages are sent for the HSRP virtual IPv6 link-local address when the HSRP group is active. These messages stop after a final one is sent when the group leaves the active state.



---

**Note** When configuring HSRP for IPv6, you must enable HSRP version 2 (HSRPv2) on the interface.

---

## EIGRP IPv6

Switches support the Enhanced Interior Gateway Routing Protocol (EIGRP) for IPv6. It is configured on the interfaces on which it runs and does not require a global IPv6 address. Switches running IP Lite only support EIGRPv6 stub routing.

Before running, an instance of EIGRP IPv6 requires an implicit or explicit router ID. An implicit router ID is derived from a local IPv6 address, so any IPv6 node always has an available router ID. However, EIGRP IPv6 might be running in a network with only IPv6 nodes and therefore might not have an available IPv6 router ID.

For more information about EIGRP for IPv6, see the “Implementing EIGRP for IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## EIGRPv6 Stub Routing

The EIGRPv6 stub routing feature, reduces resource utilization by moving routed traffic closer to the end user.

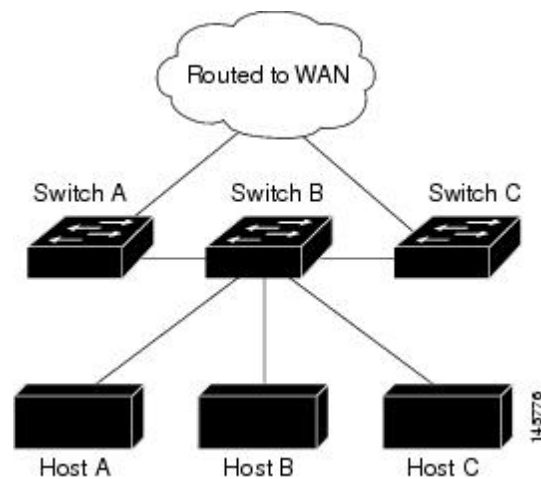
In a network using EIGRPv6 stub routing, the only allowable route for IPv6 traffic to the user is through a switch that is configured with EIGRPv6 stub routing. The switch sends the routed traffic to interfaces that are configured as user interfaces or are connected to other devices.

When using EIGRPv6 stub routing, you need to configure the distribution and remote routers to use EIGRPv6 and to configure only the switch as a stub. Only specified routes are propagated from the switch. The switch responds to all queries for summaries, connected routes, and routing updates.

Any neighbor that receives a packet informing it of the stub status does not query the stub router for any routes, and a router that has a stub peer does not query that peer. The stub router depends on the distribution router to send the proper updates to all peers.

In the figure given below, switch B is configured as an EIGRPv6 stub router. Switches A and C are connected to the rest of the WAN. Switch B advertises connected, static, redistribution, and summary routes to switch A and C. Switch B does not advertise any routes learned from switch A (and the reverse).

**Figure 9: EIGRP Stub Router Configuration**



For more information about EIGRPv6 stub routing, see “Implementing EIGRP for IPv6” section of the *Cisco IOS IP Configuration Guide, Volume 2 of 3: Routing Protocols, Release 12.4*.

## SNMP and Syslog Over IPv6

To support both IPv4 and IPv6, IPv6 network management requires both IPv6 and IPv4 transports. Syslog over IPv6 supports address data types for these transports.

Simple Network Management Protocol (SNMP) and syslog over IPv6 provide these features:

- Support for both IPv4 and IPv6
- IPv6 transport for SNMP and to modify the SNMP agent to support traps for an IPv6 host
- SNMP- and syslog-related MIBs to support IPv6 addressing
- Configuration of IPv6 hosts as trap receivers

For support over IPv6, SNMP modifies the existing IP transport mapping to simultaneously support IPv4 and IPv6. These SNMP actions support IPv6 transport management:

- Opens User Datagram Protocol (UDP) SNMP socket with default settings
- Provides a new transport mechanism called *SR\_IPV6\_TRANSPORT*
- Sends SNMP notifications over IPv6 transport
- Supports SNMP-named access lists for IPv6 transport
- Supports SNMP proxy forwarding using IPv6 transport
- Verifies SNMP Manager feature works with IPv6 transport

For information on SNMP over IPv6, including configuration procedures, see the “Managing Cisco IOS Applications over IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

For information about syslog over IPv6, including configuration procedures, see the “Implementing IPv6 Addressing and Basic Connectivity” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## HTTP(S) Over IPv6

The HTTP client sends requests to both IPv4 and IPv6 HTTP servers, which respond to requests from both IPv4 and IPv6 HTTP clients. URLs with literal IPv6 addresses must be specified in hexadecimal using 16-bit values between colons.

The accept socket call chooses an IPv4 or IPv6 address family. The accept socket is either an IPv4 or IPv6 socket. The listening socket continues to listen for both IPv4 and IPv6 signals that indicate a connection. The IPv6 listening socket is bound to an IPv6 wildcard address.

The underlying TCP/IP stack supports a dual-stack environment. HTTP relies on the TCP/IP stack and the sockets for processing network-layer interactions.

Basic network connectivity (**ping**) must exist between the client and the server hosts before HTTP connections can be made.

For more information, see the “Managing Cisco IOS Applications over IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## Unsupported IPv6 Unicast Routing Features

The switch does not support these IPv6 features:

- IPv6 packets destined to site-local addresses
- Tunneling protocols, such as IPv4-to-IPv6 or IPv6-to-IPv4
- The switch as a tunnel endpoint supporting IPv4-to-IPv6 or IPv6-to-IPv4 tunneling protocols
- IPv6 Web Cache Communication Protocol (WCCP)

## IPv6 Feature Limitations

Because IPv6 is implemented in switch hardware, some limitations occur due to the IPv6 compressed addresses in the hardware memory. These hardware limitations result in some loss of functionality and limits some features.

These are feature limitations.

- The switch cannot forward SNAP-encapsulated IPv6 packets in hardware. They are forwarded in software.
- The switch cannot apply QoS classification on source-routed IPv6 packets in hardware.

## IPv6 and Switch Stacks

The switch supports IPv6 forwarding across the stack and IPv6 host functionality on the stack master. The stack master runs the IPv6 unicast routing protocols and computes the routing tables. They receive the tables and create hardware IPv6 routes for forwarding. The stack master also runs all IPv6 applications.



### Note

To route IPv6 packets in a stack, all switches in the stack should be running the IP Base feature set.

If a new switch becomes the stack master, it recomputes the IPv6 routing tables and distributes them to the member switches. While the new stack master is being elected and is resetting, the switch stack does not forward IPv6 packets. The stack MAC address changes, which also changes the IPv6 address. When you

specify the stack IPv6 address with an extended unique identifier (EUI) by using the **ipv6 address** *ipv6-prefix/prefix length eui-64* interface configuration command, the address is based on the interface MAC address. See the [Configuring IPv6 Addressing and Enabling IPv6 Routing](#) .

If you configure the persistent MAC address feature on the stack and the stack master changes, the stack MAC address does not change for approximately 4 minutes.

These are the functions of IPv6 stack master and members:

- Stack master:
  - runs IPv6 routing protocols
  - generates routing tables
  - distributes routing tables to stack members that use distributed Cisco Express Forwarding for IPv6
  - runs IPv6 host functionality and IPv6 applications
- Stack member (must be running the IP services feature set):
  - receives Cisco Express Forwarding for IPv6 routing tables from the stack master
  - programs the routes into hardware




---

**Note** IPv6 packets are routed in hardware across the stack if the packet does not have exceptions (IPv6 Options) and the switches in the stack have not run out of hardware resources.

---

- flushes the Cisco Express Forwarding for IPv6 tables on master re-election

## Default IPv6 Configuration

*Table 20: Default IPv6 Configuration*

Feature	Default Setting
SDM template	Advance desktop. Default is advanced template
IPv6 routing	Disabled globally and on all interfaces
Cisco Express Forwarding for IPv6 or distributed Cisco Express Forwarding for IPv6	Disabled (IPv4 Cisco Express Forwarding and distributed Cisco Express Forwarding are enabled by default)  <b>Note</b> When IPv6 routing is enabled, Cisco Express Forwarding for IPv6 and distributed Cisco Express Forwarding for IPv6 are automatically enabled.
IPv6 addresses	None configured

## Configuring IPv6 Addressing and Enabling IPv6 Routing

This section describes how to assign IPv6 addresses to individual Layer 3 interfaces and to globally forward IPv6 traffic on the switch.

Before configuring IPv6 on the switch, consider these guidelines:

- Not all features discussed in this chapter are supported by the switch. See the [Unsupported IPv6 Unicast Routing Features, on page 216](#).
- In the **ipv6 address** interface configuration command, you must enter the *ipv6-address* and *ipv6-prefix* variables with the address specified in hexadecimal using 16-bit values between colons. The *prefix-length* variable (preceded by a slash [/]) is a decimal value that shows how many of the high-order contiguous bits of the address comprise the prefix (the network portion of the address).

To forward IPv6 traffic on an interface, you must configure a global IPv6 address on that interface. Configuring an IPv6 address on an interface automatically configures a link-local address and activates IPv6 for the interface. The configured interface automatically joins these required multicast groups for that link:

- solicited-node multicast group FF02:0:0:0:1:ff00::/104 for each unicast address assigned to the interface (this address is used in the neighbor discovery process.)
- all-nodes link-local multicast group FF02::1
- all-routers link-local multicast group FF02::2

To remove an IPv6 address from an interface, use the **no ipv6 address *ipv6-prefix/prefix length eui-64*** or **no ipv6 address *ipv6-address link-local*** interface configuration command. To remove all manually configured IPv6 addresses from an interface, use the **no ipv6 address** interface configuration command without arguments. To disable IPv6 processing on an interface that has not been explicitly configured with an IPv6 address, use the **no ipv6 enable** interface configuration command. To globally disable IPv6 routing, use the **no ipv6 unicast-routing** global configuration command.

For more information about configuring IPv6 routing, see the “Implementing Addressing and Basic Connectivity for IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

Beginning in privileged EXEC mode, follow these steps to assign an IPv6 address to a Layer 3 interface and enable IPv6 routing:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>sdm prefer dual-ipv4-and-ipv6 { advanced   vlan }</b> <b>Example:</b> Device(config)# <b>sdm prefer</b>	Selects an SDM template that supports IPv4 and IPv6. <ul style="list-style-type: none"> <li>• <b>advanced</b> —Sets the switch to the default template to balance system resources.</li> </ul>



	Command or Action	Purpose
	<code>dual-ipv4-and-ipv6 default</code>	<ul style="list-style-type: none"> <li>• <b>vlan</b>—Maximizes VLAN configuration on the switch with no routing supported in hardware.</li> </ul> <p><b>Note</b> Advanced is available at all license levels. VLAN template is available only in LAN Base license.</p>
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 4</b>	<b>reload</b> <b>Example:</b> Device# <b>reload</b>	Reloads the operating system.
<b>Step 5</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode after the switch reloads.
<b>Step 6</b>	<b>interface interface-id</b> <b>Example:</b> Device (config) # <b>interface</b> <b>gigabitethernet 1/0/1</b>	Enters interface configuration mode, and specifies the Layer 3 interface to configure. The interface can be a physical interface, a switch virtual interface (SVI), or a Layer 3 EtherChannel.
<b>Step 7</b>	<b>no switchport</b> <b>Example:</b> Device (config-if) # <b>no switchport</b>	Removes the interface from Layer 2 configuration mode (if it is a physical interface).
<b>Step 8</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>ipv6 address ipv6-prefix/prefix length eui-64</b></li> <li>• <b>ipv6 address ipv6-address/prefix length</b></li> <li>• <b>ipv6 address ipv6-address link-local</b></li> <li>• <b>ipv6 enable</b></li> <li>• <b>ipv6 address WORD</b></li> <li>• <b>ipv6 address autoconfig</b></li> <li>• <b>ipv6 address dhcp</b></li> </ul>	<ul style="list-style-type: none"> <li>• Specifies a global IPv6 address with an extended unique identifier (EUI) in the low-order 64 bits of the IPv6 address. Specify only the network prefix; the last 64 bits are automatically computed from the switch MAC address. This enables IPv6 processing on the interface.</li> <li>• Manually configures an IPv6 address on the interface.</li> </ul>

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config-if)# ipv6 address 2001:0DB8:c18:1::/64 eui 64</pre> <pre>Device(config-if)# ipv6 address 2001:0DB8:c18:1::/64</pre> <pre>Device(config-if)# ipv6 address 2001:0DB8:c18:1:: link-local</pre> <pre>Device(config-if)# ipv6 enable</pre>	<ul style="list-style-type: none"> <li>Specifies a link-local address on the interface to be used instead of the link-local address that is automatically configured when IPv6 is enabled on the interface. This command enables IPv6 processing on the interface.</li> <li>Automatically configures an IPv6 link-local address on the interface, and enables the interface for IPv6 processing. The link-local address can only be used to communicate with nodes on the same link.</li> </ul>
<b>Step 9</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# exit</pre>	Returns to global configuration mode.
<b>Step 10</b>	<p><b>ip routing</b></p> <p><b>Example:</b></p> <pre>Device(config)# ip routing</pre>	Enables IP routing on the switch.
<b>Step 11</b>	<p><b>ipv6 unicast-routing</b></p> <p><b>Example:</b></p> <pre>Device(config)# ipv6 unicast-routing</pre>	Enables forwarding of IPv6 unicast data packets.
<b>Step 12</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 13</b>	<p><b>show ipv6 interface <i>interface-id</i></b></p> <p><b>Example:</b></p> <pre>Device# show ipv6 interface gigabitethernet 1/0/1</pre>	Verifies your entries.
<b>Step 14</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Device# <code>copy running-config startup-config</code>	

## Configuring IPv4 and IPv6 Protocol Stacks

To configure a Layer 3 interface to support both IPv4 and IPv6 and to enable IPv6 routing, perform this procedure:.



**Note** To disable IPv6 processing on an interface that has not been configured with an IPv6 address, use the **no ipv6 enable** interface configuration command.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>ip routing</b> <b>Example:</b> Device(config)# <code>ip routing</code>	Enables routing on the switch.
<b>Step 4</b>	<b>ipv6 unicast-routing</b> <b>Example:</b> Device(config)# <code>ipv6 unicast-routing</code>	Enables forwarding of IPv6 data packets on the switch.
<b>Step 5</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <code>interface gigabitethernet 1/0/1</code>	Enters interface configuration mode, and specifies the Layer 3 interface to configure.

	Command or Action	Purpose
<b>Step 6</b>	<b>no switchport</b> <b>Example:</b> Device(config-if)# <b>no switchport</b>	Removes the interface from Layer 2 configuration mode (if it is a physical interface).
<b>Step 7</b>	<b>ip address ip-address mask [secondary]</b> <b>Example:</b> Device(config-if)# <b>ip address 10.1.2.3 255.255.255</b>	Specifies a primary or secondary IPv4 address for the interface.
<b>Step 8</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>ipv6 address ip-address/prefix length eui-64</b></li> <li>• <b>ipv6 address ip-address/prefix length</b></li> <li>• <b>ipv6 address ip-address link-local</b></li> <li>• <b>ipv6 enable</b></li> <li>• <b>ipv6 address WORD</b></li> <li>• <b>ipv6 address autoconfig</b></li> <li>• <b>ipv6 address dhcp</b></li> </ul>	<ul style="list-style-type: none"> <li>• Specifies a global IPv6 address. Specify only the network prefix; the last 64 bits are automatically computed from the switch MAC address.</li> <li>• Specifies a link-local address on the interface to be used instead of the automatically configured link-local address when IPv6 is enabled on the interface.</li> <li>• Automatically configures an IPv6 link-local address on the interface, and enables the interface for IPv6 processing. The link-local address can only be used to communicate with nodes on the same link.</li> </ul> <p><b>Note</b> To remove all manually configured IPv6 addresses from an interface, use the <b>no ipv6 address</b> interface configuration command without arguments.</p>
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 10</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>show interface interface-id</b></li> <li>• <b>show ip interface interface-id</b></li> <li>• <b>show ipv6 interface interface-id</b></li> </ul>	Verifies your entries.
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Device# <code>copy running-config startup-config</code>	

## Configuring Default Router Preference

Router advertisement messages are sent with the default router preference (DRP) configured by the **ipv6 nd router-preference** interface configuration command. If no DRP is configured, RAs are sent with a medium preference.

A DRP is useful when two routers on a link might provide equivalent, but not equal-cost routing, and policy might dictate that hosts should prefer one of the routers.

For more information about configuring DRP for IPv6, see the “Implementing IPv6 Addresses and Basic Connectivity” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

To configure a DRP for a router on an interface, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <code>enable</code>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device(config)# <code>interface gigabitethernet 1/0/1</code>	Enters interface configuration mode and identifies the Layer 3 interface on which you want to specify the DRP.
<b>Step 4</b>	<b>ipv6 nd router-preference {high   medium   low}</b> <b>Example:</b>  Device(config-if)# <code>ipv6 nd router-preference medium</code>	Specifies a DRP for the router on the switch interface.
<b>Step 5</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	Device(config)# <b>end</b>	
<b>Step 6</b>	<b>show ipv6 interface</b> <b>Example:</b> Device# <b>show ipv6 interface</b>	Verifies the configuration.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring IPv6 ICMP Rate Limiting

ICMP rate limiting is enabled by default with a default interval between error messages of 100 milliseconds and a bucket size (maximum number of tokens to be stored in a bucket) of 10.

To change the ICMP rate-limiting parameters, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 icmp error-interval <i>interval</i> [<i>bucketsize</i>]</b> <b>Example:</b> Device(config)# <b>ipv6 icmp error-interval 50 20</b>	Configures the interval and bucket size for IPv6 ICMP error messages: <ul style="list-style-type: none"> <li>• <i>interval</i>—The interval (in milliseconds) between tokens being added to the bucket. The range is from 0 to 2147483647 milliseconds.</li> <li>• <i>bucketsize</i>—(Optional) The maximum number of tokens stored in the bucket. The range is from 1 to 200.</li> </ul>

	Command or Action	Purpose
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show ipv6 interface</b> [interface-id] <b>Example:</b> Device# <b>show ipv6 interface</b> <b>gigabitethernet0/1</b>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring Cisco Express Forwarding and distributed Cisco Express Forwarding for IPv6

Cisco Express Forwarding is a Layer 3 IP switching technology to improve network performance. Cisco Express Forwarding implements an advanced IP look-up and forwarding algorithm to deliver maximum Layer 3 switching performance. It is less CPU-intensive than fast-switching route-caching, allowing more CPU processing power to be dedicated to packet forwarding. In a switch stack, the hardware uses distributed Cisco Express Forwarding in the stack. IPv4 Cisco Express Forwarding and distributed Cisco Express Forwarding are enabled by default. IPv6 Cisco Express Forwarding and distributed Cisco Express Forwarding are disabled by default, but automatically enabled when you configure IPv6 routing.

IPv6 Cisco Express Forwarding and distributed Cisco Express Forwarding are automatically disabled when IPv6 routing is unconfigured. IPv6 Cisco Express Forwarding and distributed Cisco Express Forwarding cannot be disabled through configuration. You can verify the IPv6 state by entering the **show ipv6 cef** privileged EXEC command.

To route IPv6 unicast packets, you must first globally configure forwarding of IPv6 unicast packets by using the **ipv6 unicast-routing** global configuration command, and you must configure an IPv6 address and IPv6 processing on an interface by using the **ipv6 address** interface configuration command.

For more information about configuring Cisco Express Forwarding and distributed Cisco Express Forwarding, see *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## Configuring Static Routing for IPv6

For more information about configuring static IPv6 routing, see the “Implementing Static Routes for IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

To configure static IPv6 routing, perform this procedure:

### Before you begin

You must enable routing by using the **ip routing** global configuration command, enable the forwarding of IPv6 packets by using the **ipv6 unicast-routing** global configuration command, and enable IPv6 on at least one Layer 3 interface by configuring an IPv6 address on the interface.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 route</b> <i>ipv6-prefix/prefix length</i> <i>{ipv6-address   interface-id [ipv6-address]}</i> <i>[administrative distance]</i> <b>Example:</b> Device(config)# <b>ipv6 route 2001:0DB8::/32</b> <b>gigabitethernet2/0/1 130</b>	Configures a static IPv6 route. <ul style="list-style-type: none"> <li>• <i>ipv6-prefix</i>—The IPv6 network that is the destination of the static route. It can also be a hostname when static host routes are configured.</li> <li>• <i>/prefix length</i>—The length of the IPv6 prefix. A decimal value that shows how many of the high-order contiguous bits of the address comprise the prefix (the network portion of the address). A slash mark must precede the decimal value.</li> <li>• <i>ipv6-address</i>—The IPv6 address of the next hop that can be used to reach the specified network. The IPv6 address of the next hop need not be directly connected; recursion is done to find the IPv6 address of the directly connected next hop. The address must be in the form documented in RFC 2373, specified in hexadecimal using 16-bit values between colons.</li> <li>• <i>interface-id</i>—Specifies direct static routes from point-to-point and broadcast interfaces. With point-to-point interfaces, there is no need to specify the IPv6 address of the next hop. With broadcast interfaces, you should always specify the IPv6 address of the next hop, or ensure that the specified prefix is assigned to the link,</li> </ul>



	Command or Action	Purpose
		<p>specifying a link-local address as the next hop. You can optionally specify the IPv6 address of the next hop to which packets are sent.</p> <p><b>Note</b> You must specify an <i>interface-id</i> when using a link-local address as the next hop (the link-local next hop must also be an adjacent router).</p> <ul style="list-style-type: none"> <li>• <i>administrative distance</i>—(Optional) An administrative distance. The range is 1 to 254; the default value is 1, which gives static routes precedence over any other type of route except connected routes. To configure a floating static route, use an administrative distance greater than that of the dynamic routing protocol.</li> </ul>
<b>Step 4</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 5</b>	<p>Use one of the following:</p> <ul style="list-style-type: none"> <li>• <b>show ipv6 static</b> [ <i>ipv6-address</i>   <i>ipv6-prefix/prefix length</i> ] [<b>interface</b> <i>interface-id</i>] [<b>detail</b>][<b>recursive</b>] [<b>detail</b>]</li> <li>• <b>show ipv6 route static</b> [<i>updated</i>]</li> </ul> <p><b>Example:</b></p> <pre>Device# show ipv6 static 2001:0DB8::/32 interface gigabitethernet2/0/1</pre> <p>or</p> <pre>Device# show ipv6 route static</pre>	<p>Verifies your entries by displaying the contents of the IPv6 routing table.</p> <ul style="list-style-type: none"> <li>• <b>interface</b> <i>interface-id</i>—(Optional) Displays only those static routes with the specified interface as an egress interface.</li> <li>• <b>recursive</b>—(Optional) Displays only recursive static routes. The <b>recursive</b> keyword is mutually exclusive with the <b>interface</b> keyword, but it can be used with or without the IPv6 prefix included in the command syntax.</li> <li>• <b>detail</b>—(Optional) Displays this additional information: <ul style="list-style-type: none"> <li>• For valid recursive routes, the output path set, and maximum resolution depth.</li> <li>• For invalid routes, the reason why the route is not valid.</li> </ul> </li> </ul>

	Command or Action	Purpose
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Enabling IPv6 PBR on an Interface

To enable Policy-Based Routing (PBR) for IPv6, you must create a route map that specifies the packet match criteria and desired policy-route action. Then you associate the route map on the required interface. All packets arriving on the specified interface that match the match clauses will be subject to PBR.

In PBR, the **set vrf** command decouples the virtual routing and forwarding (VRF) instance and interface association and allows the selection of a VRF based on access control list (ACL)-based classification using existing PBR or route-map configurations. It provides a single router with multiple routing tables and the ability to select routes based on ACL classification. The router classifies packets based on ACL, selects a routing table, looks up the destination address, and then routes the packet.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>route-map map-tag [permit   deny]</b> <b>[sequence-number]</b> <b>Example:</b> <pre>Device(config)# route-map rip-to-ospf permit</pre>	Defines the conditions for redistributing routes from one routing protocol into another, or enables policy routing, and enters route-map configuration mode.
<b>Step 4</b>	Do one of the following: <ul style="list-style-type: none"> <li>• <b>match length</b> <i>minimum-length</i> <i>maximum-length</i></li> <li>• <b>match ipv6 address</b> {<i>prefix-list</i> <i>prefix-list-name</i>   <i>access-list-name</i>}</li> </ul> <b>Example:</b>	Specifies the match criteria. <ul style="list-style-type: none"> <li>• You can specify any or all of the following:               <ul style="list-style-type: none"> <li>• Matches the Level 3 length of the packet.</li> <li>• Matches a specified IPv6 access list.</li> </ul> </li> </ul>

	Command or Action	Purpose
	<pre>Device(config-route-map)# match length 3 200</pre> <p><b>Example:</b></p> <pre>Device(config-route-map)# match ipv6 address marketing</pre>	<ul style="list-style-type: none"> <li>If you do not specify a <b>match</b> command, the route map applies to all packets.</li> </ul>
<b>Step 5</b>	<p>Do one of the following:</p> <ul style="list-style-type: none"> <li><b>set ipv6 precedence</b> <i>precedence-value</i></li> <li><b>set ipv6 next-hop</b> <i>global-ipv6-address</i> [<i>global-ipv6-address...</i>]</li> <li><b>set interface</b> <i>type number</i> [<i>...type number</i>]</li> <li><b>set ipv6 default next-hop</b> <i>global-ipv6-address</i> [<i>global-ipv6-address...</i>]</li> <li><b>set default interface</b> <i>type number</i> [<i>...type number</i>]</li> <li><b>set vrf</b> <i>vrf-name</i></li> </ul> <p><b>Example:</b></p> <pre>Device(config-route-map)# set ipv6 precedence 1</pre> <p><b>Example:</b></p> <pre>Device(config-route-map)# set ipv6 next-hop 2001:DB8:2003:1::95</pre> <p><b>Example:</b></p> <pre>Device(config-route-map)# set interface GigabitEthernet 0/0/1</pre> <p><b>Example:</b></p> <pre>Device(config-route-map)# set ipv6 default next-hop 2001:DB8:2003:1::95</pre> <p><b>Example:</b></p> <pre>Device(config-route-map)# set default interface GigabitEthernet 0/0/0</pre> <p><b>Example:</b></p> <pre>Device(config-route-map)# set vrf vrfname</pre>	<p>Specifies the action or actions to take on the packets that match the criteria.</p> <ul style="list-style-type: none"> <li>You can specify any or all of the following: <ul style="list-style-type: none"> <li>Sets precedence value in the IPv6 header.</li> <li>Sets next hop to which to route the packet (the next hop must be adjacent).</li> <li>Sets output interface for the packet.</li> <li>Sets next hop to which to route the packet, if there is no explicit route for this destination.</li> <li>Sets output interface for the packet, if there is no explicit route for this destination.</li> <li>Sets VRF instance selection within a route map for a policy-based routing VRF selection.</li> </ul> </li> </ul>
<b>Step 6</b>	<p><b>exit</b></p> <p><b>Example:</b></p>	<p>Exits route-map configuration mode and returns to global configuration mode.</p>

	Command or Action	Purpose
	<code>Device(config-route-map)# exit</code>	
<b>Step 7</b>	<b>interface</b> <i>type number</i> <b>Example:</b> <code>Device(config)# interface FastEthernet 1/0</code>	Specifies an interface type and number, and places the router in interface configuration mode.
<b>Step 8</b>	<b>ipv6 policy route-map</b> <i>route-map-name</i> <b>Example:</b> <code>Device(config-if)# ipv6 policy-route-map interactive</code>	Identifies a route map to use for IPv6 PBR on an interface.
<b>Step 9</b>	<b>end</b> <b>Example:</b> <code>Device(config-if)# end</code>	Exits interface configuration mode and returns to privileged EXEC mode.

## Enabling Local PBR for IPv6

Packets that are generated by the device are not normally policy routed. Perform this task to enable local IPv6 policy-based routing (PBR) for such packets, indicating which route map the device should use.

To enable Local PBR for IPv6, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <code>Device&gt; enable</code>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <code>Device# configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 local policy route-map</b> <i>route-map-name</i> <b>Example:</b> <code>Device(config)# ipv6 local policy route-map pbr-src-90</code>	Configures IPv6 PBR for packets generated by the device.
<b>Step 4</b>	<b>end</b> <b>Example:</b> <code>Device(config)# end</code>	Returns to privileged EXEC mode.

## Configuring RIP for IPv6

For more information about configuring RIP routing for IPv6, see the “Implementing RIP for IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com,

To configure RIP routing for IPv6, perform this procedure:

### Before you begin

Before configuring the switch to run IPv6 RIP, you must enable routing by using the **ip routing** global configuration command, enable the forwarding of IPv6 packets by using the **ipv6 unicast-routing** global configuration command, and enable IPv6 on any Layer 3 interfaces on which IPv6 RIP is to be enabled.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 router rip name</b> <b>Example:</b>  Device(config)# <b>ipv6 router rip cisco</b>	Configures an IPv6 RIP routing process, and enters router configuration mode for the process.
<b>Step 4</b>	<b>maximum-paths number-paths</b> <b>Example:</b>  Device(config-router)# <b>maximum-paths 6</b>	(Optional) Define the maximum number of equal-cost routes that IPv6 RIP can support. The range is from 1 to 32, and the default is 16 routes.
<b>Step 5</b>	<b>exit</b> <b>Example:</b>  Device(config-router)# <b>exit</b>	Returns to global configuration mode.
<b>Step 6</b>	<b>interface interface-id</b> <b>Example:</b>  Device(config)# <b>interface</b> <b>gigabitethernet 1/0/1</b>	Enters interface configuration mode, and specifies the Layer 3 interface to configure.

	Command or Action	Purpose
<b>Step 7</b>	<b>ipv6 rip name enable</b> <b>Example:</b> <pre>Device(config-if)# ipv6 rip cisco enable</pre>	Enables the specified IPv6 RIP routing process on the interface.
<b>Step 8</b>	<b>ipv6 rip name default-information {only   originate}</b> <b>Example:</b> <pre>Device(config-if)# ipv6 rip cisco default-information only</pre>	(Optional) Originates the IPv6 default route (::/0) into the RIP routing process updates sent from the specified interface.  <b>Note</b> To avoid routing loops after the IPv6 default route (::/0) is originated from any interface, the routing process ignores all default routes received on any interface.  <ul style="list-style-type: none"> <li>• <b>only</b>—Select to originate the default route, but suppress all other routes in the updates sent on this interface.</li> <li>• <b>originate</b>—Select to originate the default route in addition to all other routes in the updates sent on this interface.</li> </ul>
<b>Step 9</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 10</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>show ipv6 rip [name] [ interface interface-id] [ database ] [ next-hops ]</b></li> <li>• <b>show ipv6 rip</b></li> </ul> <b>Example:</b> <pre>Device# show ipv6 rip cisco interface gigabitethernet 2/0/1</pre> or <pre>Device# show ipv6 rip</pre>	<ul style="list-style-type: none"> <li>• Displays information about current IPv6 RIP processes.</li> <li>• Displays the current contents of the IPv6 routing table.</li> </ul>
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring OSPF for IPv6

For more information about configuring OSPF routing for IPv6, see the “Implementing OSPF for IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

To configure OSPF routing for IPv6, perform this procedure:

### Before you begin

You can customize OSPF for IPv6 for your network. However, the defaults for OSPF in IPv6 are set to meet the requirements of most customers and features.

Follow these guidelines:

- Be careful when changing the defaults for IPv6 commands. Changing the defaults might adversely affect OSPF for the IPv6 network.
- Before you enable IPv6 OSPF on an interface, you must enable routing by using the **ip routing** global configuration command, enable the forwarding of IPv6 packets by using the **ipv6 unicast-routing** global configuration command, and enable IPv6 on Layer 3 interfaces on which you are enabling IPv6 OSPF.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 router ospf process-id</b> <b>Example:</b> Device(config)# <b>ipv6 router ospf 21</b>	Enables OSPF router configuration mode for the process. The process ID is the number assigned administratively when enabling the OSPF for IPv6 routing process. It is locally assigned and can be a positive integer from 1 to 65535.
<b>Step 4</b>	<b>area area-id range {ipv6-prefix/prefix length} [advertise   not-advertise] [cost cost]</b> <b>Example:</b> Device(config)# <b>area .3 range 2001:0DB8::/32 not-advertise</b>	(Optional) Consolidates and summarizes routes at an area boundary. <ul style="list-style-type: none"> <li>• <i>area-id</i>—Identifier of the area about which routes are to be summarized. It can be specified as either a decimal value or as an IPv6 prefix.</li> <li>• <i>ipv6-prefix/prefix length</i>—The destination IPv6 network and a decimal value that shows how many of the high-order</li> </ul>

	Command or Action	Purpose
		<p>contiguous bits of the address comprise the prefix (the network portion of the address). A slash mark (/) must precede the decimal value.</p> <ul style="list-style-type: none"> <li>• <b>advertise</b>—(Optional) Sets the address range status to advertise and generate a Type 3 summary link-state advertisement (LSA).</li> <li>• <b>not-advertise</b>—(Optional) Sets the address range status to DoNotAdvertise. The Type 3 summary LSA is suppressed, and component networks remain hidden from other networks.</li> <li>• <b>cost cost</b>—(Optional) Sets the metric or cost for this summary route, which is used during OSPF SPF calculation to determine the shortest paths to the destination. The value can be 0 to 16777215.</li> </ul>
<b>Step 5</b>	<p><b>maximum paths</b> <i>number-paths</i></p> <p><b>Example:</b></p> <pre>Device(config)# maximum paths 16</pre>	(Optional) Defines the maximum number of equal-cost routes to the same destination that IPv6 OSPF should enter in the routing table. The range is from 1 to 32, and the default is 16 paths.
<b>Step 6</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# exit</pre>	Returns to global configuration mode.
<b>Step 7</b>	<p><b>interface</b> <i>interface-id</i></p> <p><b>Example:</b></p> <pre>Device(config)# interface gigabitethernet 1/0/1</pre>	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
<b>Step 8</b>	<p><b>ipv6 ospf</b> <i>process-id area area-id [instance instance-id]</i></p> <p><b>Example:</b></p> <pre>Device(config-if)# ipv6 ospf 21 area .3</pre>	<p>Enables OSPF for IPv6 on the interface.</p> <ul style="list-style-type: none"> <li>• <b>instance instance-id</b>—(Optional) Instance identifier.</li> </ul>



	Command or Action	Purpose
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 10</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>show ipv6 ospf</b> [ <i>process-id</i> ] [ <i>area-id</i> ] <b>interface</b> [ <i>interface-id</i> ]</li> <li>• <b>show ipv6 ospf</b> [ <i>process-id</i> ] [ <i>area-id</i> ]</li> </ul> <b>Example:</b> Device# <b>show ipv6 ospf 21 interface gigabitethernet2/0/1</b> or Device# <b>show ipv6 ospf 21</b>	<ul style="list-style-type: none"> <li>• Displays information about OSPF interfaces.</li> <li>• Displays general information about OSPF routing processes.</li> </ul>
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring EIGRP for IPv6

Before configuring the switch to run IPv6 EIGRP, enable routing by entering the **ip routing global configuration** command, enable the forwarding of IPv6 packets by entering the **ipv6 unicast-routing global configuration** command, and enable IPv6 on any Layer 3 interfaces on which you want to enable IPv6 EIGRP.

To set an explicit router ID, use the **show ipv6 eigrp** command to see the configured router IDs, and then use the **router-id** command.

As with EIGRP IPv4, you can use EIGRPv6 to specify your EIGRP IPv6 interfaces and to select a subset of those as passive interfaces. Use the **passive-interface** command to make an interface passive, and then use the **no passive-interface** command on selected interfaces to make them active. EIGRP IPv6 does not need to be configured on a passive interface.

For more configuration procedures, see the “Implementing EIGRP for IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

## Configuring IPv6 Unicast Reverse Path Forwarding

The unicast Reverse Path Forwarding (unicast RPF) feature helps to mitigate problems that are caused by the introduction of malformed or forged (spoofed) IP source addresses into a network by discarding IP packets that lack a verifiable IP source address. For example, a number of common types of denial-of-service (DoS)

attacks, including Smurf and Tribal Flood Network (TFN), can take advantage of forged or rapidly changing source IP addresses to allow attackers to thwart efforts to locate or filter the attacks. For Internet service providers (ISPs) that provide public access, Unicast RPF deflects such attacks by forwarding only packets that have source addresses that are valid and consistent with the IP routing table. This action protects the network of the ISP, its customer, and the rest of the Internet.

**Note**

- Unicast RPF is supported only in IP services.
- Do not configure Unicast RPF if the switch is in a mixed hardware stack combining more than one switch type.

For detailed IP unicast RPF configuration information, see the *Other Security Features* chapter in the *Cisco IOS Security Configuration Guide, Release 12.4*.

## Displaying IPv6

For complete syntax and usage information on these commands, see the Cisco IOS command reference publications.

**Table 21: Command for Monitoring IPv6**

Command	Purpose
<b>show ipv6 access-list</b>	Displays a summary of access lists.
<b>show ipv6 cef</b>	Displays Cisco Express Forwarding for IPv6.
<b>show ipv6 interface <i>interface-id</i></b>	Displays IPv6 interface status and configuration.
<b>show ipv6 mtu</b>	Displays IPv6 MTU per destination cache.
<b>show ipv6 neighbors</b>	Displays IPv6 neighbor cache entries.
<b>show ipv6 ospf</b>	Displays IPv6 OSPF information.
<b>show ipv6 prefix-list</b>	Displays a list of IPv6 prefix lists.
<b>show ipv6 protocols</b>	Displays a list of IPv6 routing protocols on the switch.
<b>show ipv6 rip</b>	Displays IPv6 RIP routing protocol status.
<b>show ipv6 rip</b>	Displays IPv6 RIP routing protocol status.
<b>show ipv6 route</b>	Displays IPv6 route table entries.
<b>show ipv6 routers</b>	Displays the local IPv6 routers.
<b>show ipv6 static</b>	Displays IPv6 static routes.
<b>show ipv6 traffic</b>	Displays IPv6 traffic statistics.

Table 22: Command for Displaying EIGRP IPv6 Information

Command	Purpose
<code>show ipv6 eigrp [as-number] interface</code>	Displays information about interfaces configured for EIGRP IPv6.
<code>show ipv6 eigrp [as-number] neighbor</code>	Displays the neighbors discovered by EIGRP IPv6.
<code>show ipv6 interface[as-number] traffic</code>	Displays the number of EIGRP IPv6 packets sent and received.
<code>show ipv6 eigrptopology [as-number   ipv6-address] [active   all-links   detail-links   pending   summary   zero-successors   Base]</code>	Displays EIGRP entries in the IPv6 topology table.

## Configuring DHCP for IPv6 Address Assignment

This section describes only the DHCPv6 address assignment. For more information about configuring the DHCPv6 client, server, or relay agent functions, see the “Implementing DHCP for IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

### Default DHCPv6 Address Assignment Configuration

By default, no DHCPv6 features are configured on the switch.

### DHCPv6 Address Assignment Configuration Guidelines

When configuring DHCPv6 address assignment, consider these guidelines:

- In the procedures, the specified interface must be one of these Layer 3 interfaces:
  - DHCPv6 IPv6 routing must be enabled on a Layer 3 interface.
  - SVI: a VLAN interface created by using the `interface vlan vlan_id` command.
  - EtherChannel port channel in Layer 3 mode: a port-channel logical interface created by using the `interface port-channel port-channel-number` command.
- The switch can act as a DHCPv6 client, server, or relay agent. The DHCPv6 client, server, and relay function are mutually exclusive on an interface.
- The DHCPv6 client, server, or relay agent runs only on the master switch. When there is a stack master re-election, the new master switch retains the DHCPv6 configuration. However, the local RAM copy of the DHCP server database lease information is not retained.
- Beginning from Cisco IOS XE Gibraltar 16.11.1, an autoconfigured IPv6 address will contain interface identifiers that are not part of the reserved interface identifiers range specified in RFC5453.

## Enabling DHCPv6 Server Function (CLI)

Use the **no** form of the DHCP pool configuration mode commands to change the DHCPv6 pool characteristics. To disable the DHCPv6 server function on an interface, use the **no ipv6 dhcp server** interface configuration command.

To enable the DHCPv6 server function on an interface, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 dhcp pool poolname</b> <b>Example:</b>  Device(config)# <b>ipv6 dhcp pool 7</b>	Enters DHCP pool configuration mode, and define the name for the IPv6 DHCP pool. The pool name can be a symbolic string (such as Engineering) or an integer (such as 0).
<b>Step 4</b>	<b>address prefix IPv6-prefix {lifetime} {t1 t1   infinite}</b> <b>Example:</b>  Device(config-dhcpv6)# <b>address prefix 2001:1000::0/64 lifetime 3600</b>	(Optional) Specifies an address prefix for address assignment.  This address must be in hexadecimal, using 16-bit values between colons.  <b>lifetime t1 t1</b> —Specifies a time interval (in seconds) that an IPv6 address prefix remains in the valid state. The range is 5 to 4294967295 seconds. Specify <b>infinite</b> for no time interval.
<b>Step 5</b>	<b>link-address IPv6-prefix</b> <b>Example:</b>  Device(config-dhcpv6)# <b>link-address 2001:1002::0/64</b>	(Optional) Specifies a link-address IPv6 prefix.  When an address on the incoming interface or a link-address in the packet matches the specified IPv6 prefix, the server uses the configuration information pool.  This address must be in hexadecimal, using 16-bit values between colons.
<b>Step 6</b>	<b>vendor-specific vendor-id</b> <b>Example:</b>  Device(config-dhcpv6)# <b>vendor-specific</b>	(Optional) Enters vendor-specific configuration mode and specifies a vendor-specific identification number. This number is the

	Command or Action	Purpose
	9	vendor IANA Private Enterprise Number. The range is 1 to 4294967295.
<b>Step 7</b>	<b>suboption</b> <i>number</i> { <b>address</b> <i>IPv6-address</i>   <b>ascii</b> <i>ASCII-string</i>   <b>hex</b> <i>hex-string</i> } <b>Example:</b> <pre>Device(config-dhcpv6-vs)# <b>suboption 1</b> <b>address 1000:235D::</b></pre>	(Optional) Enters a vendor-specific suboption number. The range is 1 to 65535. Enter an IPv6 address, ASCII text, or a hex string as defined by the suboption parameters.
<b>Step 8</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-dhcpv6-vs)# <b>exit</b></pre>	Returns to DHCP pool configuration mode.
<b>Step 9</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-dhcpv6)# <b>exit</b></pre>	Returns to global configuration mode.
<b>Step 10</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> <pre>Device(config)# <b>interface</b> <b>gigabitethernet 1/0/1</b></pre>	Enters interface configuration mode, and specifies the interface to configure.
<b>Step 11</b>	<b>ipv6 dhcp server</b> [ <i>poolname</i>   <b>automatic</b> ] [ <b>rapid-commit</b> ] [ <b>preference</b> <i>value</i> ] [ <b>allow-hint</b> ] <b>Example:</b> <pre>Device(config-if)# <b>ipv6 dhcp server</b> <b>automatic</b></pre>	<p>Enables DHCPv6 server function on an interface.</p> <ul style="list-style-type: none"> <li>• <b>poolname</b>—(Optional) User-defined name for the IPv6 DHCP pool. The pool name can be a symbolic string (such as Engineering) or an integer (such as 0).</li> <li>• <b>automatic</b>—(Optional) Enables the system to automatically determine which pool to use when allocating addresses for a client.</li> <li>• <b>rapid-commit</b>—(Optional) Allows two-message exchange method.</li> <li>• <b>preference value</b>—(Optional) Configures the preference value carried in the preference option in the advertise message sent by the server. The range is from 0 to 255. The preference value default is 0.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>allow-hint</b>—(Optional) Specifies whether the server should consider client suggestions in the SOLICIT message. By default, the server ignores client hints.</li> </ul>
<b>Step 12</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 13</b>	Do one of the following: <ul style="list-style-type: none"> <li>• <b>show ipv6 dhcp pool</b></li> <li>• <b>show ipv6 dhcp interface</b></li> </ul> <b>Example:</b> Device# <b>show ipv6 dhcp pool</b> or Device# <b>show ipv6 dhcp interface</b>	<ul style="list-style-type: none"> <li>• Verifies DHCPv6 pool configuration.</li> <li>• Verifies that the DHCPv6 server function is enabled on an interface.</li> </ul>
<b>Step 14</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Enabling DHCPv6 Client Function

To enable the DHCPv6 client on an interface, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> Device(config)# <b>interface</b> gigabitethernet 1/0/1	Enters interface configuration mode, and specifies the interface to configure.
<b>Step 4</b>	<b>ipv6 address dhcp</b> [rapid-commit] <b>Example:</b> Device(config-if)# <b>ipv6 address dhcp</b> <b>rapid-commit</b>	Enables the interface to acquire an IPv6 address from the DHCPv6 server.  <b>rapid-commit</b> —(Optional) Allow two-message exchange method for address assignment.
<b>Step 5</b>	<b>ipv6 dhcp client request</b> [vendor-specific] <b>Example:</b> Device(config-if)# <b>ipv6 dhcp client</b> <b>request vendor-specific</b>	(Optional) Enables the interface to request the vendor-specific option.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show ipv6 dhcp interface</b> <b>Example:</b> Device# <b>show ipv6 dhcp interface</b>	Verifies that the DHCPv6 client is enabled on an interface.

## Configuration Examples for IPv6 Unicast Routing

### Configuring IPv6 Addressing and Enabling IPv6 Routing: Example

This example shows how to enable IPv6 with both a link-local address and a global address based on the IPv6 prefix 2001:0DB8:c18:1::/64. The EUI-64 interface ID is used in the low-order 64 bits of both addresses. Output from the **show ipv6 interface** EXEC command is included to show how the interface ID (20B:46FF:FE2F:D940) is appended to the link-local prefix FE80::/64 of the interface.

```
Device(config)# ipv6 unicast-routing
Device(config)# interface gigabitethernet0/11
Device(config-if)# no switchport
Device(config-if)# ipv6 address 2001:0DB8:c18:1::/64 eui 64
Device(config-if)# end
```

```

Device# show ipv6 interface gigabitethernet0/11
GigabitEthernet0/11 is up, line protocol is up
IPv6 is enabled, link-local address is FE80::20B:46FF:FE2F:D940
Global unicast address(es):
2001:0DB8:c18:1:20B:46FF:FE2F:D940, subnet is 2001:0DB8:c18:1::/64 [EUI]
Joined group address(es):
FF02::1
FF02::2
FF02::1:FF2F:D940
MTU is 1500 bytes
ICMP error messages limited to one every 100 milliseconds
ICMP redirects are enabled
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds
ND advertised reachable time is 0 milliseconds
ND advertised retransmit interval is 0 milliseconds
ND router advertisements are sent every 200 seconds
ND router advertisements live for 1800 seconds
Hosts use stateless autoconfig for addresses.

```

## Configuring Default Router Preference: Example

This example shows how to configure a DRP of *high* for the router on an interface.

```

Device# configure terminal
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ipv6 nd router-preference high
Device(config-if)# end

```

## Configuring IPv4 and IPv6 Protocol Stacks: Example

This example shows how to enable IPv4 and IPv6 routing on an interface.

```

Device(config)# ip routing
Device(config)# ipv6 unicast-routing
Device(config)# interface fastethernet1/0/11
Device(config-if)# no switchport
Device(config-if)# ip address 192.168.99.1 255.255.255.0
Device(config-if)# ipv6 address 2001:0DB8:c18:1::/64 eui 64
Device(config-if)# end

```

## Enabling DHCPv6 Server Function: Example

This example shows how to configure a pool called *engineering* with an IPv6 address prefix:

```

Device# configure terminal
Device(config)# ipv6 dhcp pool engineering
Device(config-dhcpv6)#address prefix 2001:1000::0/64
Device(config-dhcpv6)# end

```



This example shows how to configure a pool called *testgroup* with three link-addresses and an IPv6 address prefix:

```
Device# configure terminal
Device(config)# ipv6 dhcp pool testgroup
Device(config-dhcpv6)# link-address 2001:1001::0/64
Device(config-dhcpv6)# link-address 2001:1002::0/64
Device(config-dhcpv6)# link-address 2001:2000::0/48
Device(config-dhcpv6)# address prefix 2001:1003::0/64
Device(config-dhcpv6)# end
```

This example shows how to configure a pool called *350* with vendor-specific options:

```
Device# configure terminal
Device(config)# ipv6 dhcp pool 350
Device(config-dhcpv6)# address prefix 2001:1005::0/48
Device(config-dhcpv6)# vendor-specific 9
Device(config-dhcpv6-vs)# suboption 1 address 1000:235D::1
Device(config-dhcpv6-vs)# suboption 2 ascii "IP-Phone"
Device(config-dhcpv6-vs)# end
```

## Enabling DHCPv6 Client Function: Example

This example shows how to acquire an IPv6 address and to enable the rapid-commit option:

```
Device(config)# interface gigabitethernet2/0/1
Device(config-if)# ipv6 address dhcp rapid-commit
```

## Configuring IPv6 ICMP Rate Limiting: Example

This example shows how to configure an IPv6 ICMP error message interval of 50 milliseconds and a bucket size of 20 tokens.

```
Device(config)#ipv6 icmp error-interval 50 20
```

## Configuring Static Routing for IPv6: Example

This example shows how to configure a floating static route to an interface with an administrative distance of 130:

```
Device(config)# ipv6 route 2001:0DB8::/32 gigabitethernet 1/0/1 130
```

## Example: Enabling PBR on an Interface

In the following example, a route map named *pbr-dest-1* is created and configured, specifying packet match criteria and desired policy-route action. PBR is then enabled on GigabitEthernet interface 0/0/1.

```

ipv6 access-list match-dest-1
 permit ipv6 any 2001:DB8:2001:1760::/32
route-map pbr-dest-1 permit 10
 match ipv6 address match-dest-1
 set interface GigabitEthernet 0/0/0
interface GigabitEthernet0/0/1
 ipv6 policy-route-map interactive

```

## Example: Enabling Local PBR for IPv6

In the following example, packets with a destination IPv6 address that match the IPv6 address range allowed by access list pbr-src-90 are sent to the device at IPv6 address 2001:DB8:2003:1::95:

```

ipv6 access-list src-90
 permit ipv6 host 2001:DB8:2003::90 2001:DB8:2001:1000::/64
route-map pbr-src-90 permit 10
 match ipv6 address src-90
 set ipv6 next-hop 2001:DB8:2003:1::95
ipv6 local policy route-map pbr-src-90

```

## Configuring RIP for IPv6: Example

This example shows how to enable the RIP routing process *cisco* with a maximum of eight equal-cost routes and to enable it on an interface:

```

Device(config)# ipv6 router rip cisco
Device(config-router)# maximum-paths 8
Device(config)# exit
Device(config)# interface gigabitethernet2/0/11
Device(config-if)# ipv6 rip cisco enable

```

## Displaying IPv6: Example

This is an example of the output from the **show ipv6 interface** privileged EXEC command:

```

Device# show ipv6 interface
Vlan1 is up, line protocol is up
 IPv6 is enabled, link-local address is FE80::20B:46FF:FE2F:D940
Global unicast address(es):
 3FFE:C000:0:1:20B:46FF:FE2F:D940, subnet is 3FFE:C000:0:1::/64 [EUI]
Joined group address(es):
 FF02::1
 FF02::2
 FF02::1:FF2F:D940
MTU is 1500 bytes
ICMP error messages limited to one every 100 milliseconds
ICMP redirects are enabled
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds
ND advertised reachable time is 0 milliseconds
ND advertised retransmit interval is 0 milliseconds
ND router advertisements are sent every 200 seconds
ND router advertisements live for 1800 seconds

```

<output truncated>





## CHAPTER 16

# Implementing IPv6 Multicast

- [Information About Implementing IPv6 Multicast Routing, on page 247](#)
- [Implementing IPv6 Multicast, on page 254](#)

## Information About Implementing IPv6 Multicast Routing

This chapter describes how to implement IPv6 multicast routing on the switch.

Traditional IP communication allows a host to send packets to a single host (unicast transmission) or to all hosts (broadcast transmission). IPv6 multicast provides a third scheme, allowing a host to send a single data stream to a subset of all hosts (group transmission) simultaneously.

## IPv6 Multicast Overview

An IPv6 multicast group is an arbitrary group of receivers that want to receive a particular data stream. This group has no physical or geographical boundaries--receivers can be located anywhere on the Internet or in any private network. Receivers that are interested in receiving data flowing to a particular group must join the group by signaling their local switch. This signaling is achieved with the MLD protocol.

Switches use the MLD protocol to learn whether members of a group are present on their directly attached subnets. Hosts join multicast groups by sending MLD report messages. The network then delivers data to a potentially unlimited number of receivers, using only one copy of the multicast data on each subnet. IPv6 hosts that wish to receive the traffic are known as group members.

Packets delivered to group members are identified by a single multicast group address. Multicast packets are delivered to a group using best-effort reliability, just like IPv6 unicast packets.

The multicast environment consists of senders and receivers. Any host, regardless of whether it is a member of a group, can send to a group. However, only members of a group can listen to and receive the message.

A multicast address is chosen for the receivers in a multicast group. Senders use that address as the destination address of a datagram to reach all members of the group.

Membership in a multicast group is dynamic; hosts can join and leave at any time. There is no restriction on the location or number of members in a multicast group. A host can be a member of more than one multicast group at a time.

How active a multicast group is, its duration, and its membership can vary from group to group and from time to time. A group that has members may have no activity.

## IPv6 Multicast Routing Implementation

The Cisco IOS software supports the following protocols to implement IPv6 multicast routing:

- MLD is used by IPv6 switches to discover multicast listeners (nodes that want to receive multicast packets destined for specific multicast addresses) on directly attached links. There are two versions of MLD: MLD version 1 is based on version 2 of the Internet Group Management Protocol (IGMP) for IPv4, and MLD version 2 is based on version 3 of the IGMP for IPv4. IPv6 multicast for Cisco IOS software uses both MLD version 2 and MLD version 1. MLD version 2 is fully backward-compatible with MLD version 1 (described in RFC 2710). Hosts that support only MLD version 1 will interoperate with a switch running MLD version 2. Mixed LANs with both MLD version 1 and MLD version 2 hosts are likewise supported.
- PIM-SM is used between switches so that they can track which multicast packets to forward to each other and to their directly connected LANs.
- PIM in Source Specific Multicast (PIM-SSM) is similar to PIM-SM with the additional ability to report interest in receiving packets from specific source addresses (or from all but the specific source addresses) to an IP multicast address.

### IPv6 Multicast Listener Discovery Protocol

To start implementing multicasting in the campus network, users must first define who receives the multicast. The MLD protocol is used by IPv6 switches to discover the presence of multicast listeners (for example, nodes that want to receive multicast packets) on their directly attached links, and to discover specifically which multicast addresses are of interest to those neighboring nodes. It is used for discovering local group and source-specific group membership.

The MLD protocol provides a means to automatically control and limit the flow of multicast traffic throughout your network with the use of special multicast queriers and hosts.

### Multicast Queriers and Hosts

A multicast querier is a network device, such as a switch, that sends query messages to discover which network devices are members of a given multicast group.

A multicast host is a receiver, including switches, that send report messages to inform the querier of a host membership.

A set of queriers and hosts that receive multicast data streams from the same source is called a multicast group. Queriers and hosts use MLD reports to join and leave multicast groups and to begin receiving group traffic.

MLD uses the Internet Control Message Protocol (ICMP) to carry its messages. All MLD messages are link-local with a hop limit of 1, and they all have the switch alert option set. The switch alert option implies an implementation of the hop-by-hop option header.

### MLD Access Group

The MLD access group provides receiver access control in Cisco IOS IPv6 multicast switches. This feature limits the list of groups a receiver can join, and it allows or denies sources used to join SSM channels.

### Explicit Tracking of Receivers

The explicit tracking feature allows a switch to track the behavior of the hosts within its IPv6 network. This feature also enables the fast leave mechanism to be used with MLD version 2 host reports.

## Protocol Independent Multicast

Protocol Independent Multicast (PIM) is used between switches so that they can track which multicast packets to forward to each other and to their directly connected LANs. PIM works independently of the unicast routing protocol to perform send or receive multicast route updates like other protocols. Regardless of which unicast routing protocols are being used in the LAN to populate the unicast routing table, Cisco IOS PIM uses the existing unicast table content to perform the Reverse Path Forwarding (RPF) check instead of building and maintaining its own separate routing table.

You can configure IPv6 multicast to use either PIM-SM or PIM-SSM operation, or you can use both PIM-SM and PIM-SSM together in your network.

### PIM-Sparse Mode

IPv6 multicast provides support for intradomain multicast routing using PIM-SM. PIM-SM uses unicast routing to provide reverse-path information for multicast tree building, but it is not dependent on any particular unicast routing protocol.

PIM-SM is used in a multicast network when relatively few switches are involved in each multicast and these switches do not forward multicast packets for a group, unless there is an explicit request for the traffic. PIM-SM distributes information about active sources by forwarding data packets on the shared tree. PIM-SM initially uses shared trees, which requires the use of an RP.

Requests are accomplished via PIM joins, which are sent hop by hop toward the root node of the tree. The root node of a tree in PIM-SM is the RP in the case of a shared tree or the first-hop switch that is directly connected to the multicast source in the case of a shortest path tree (SPT). The RP keeps track of multicast groups and the hosts that send multicast packets are registered with the RP by that host's first-hop switch.

As a PIM join travels up the tree, switches along the path set up multicast forwarding state so that the requested multicast traffic will be forwarded back down the tree. When multicast traffic is no longer needed, a switch sends a PIM prune up the tree toward the root node to prune (or remove) the unnecessary traffic. As this PIM prune travels hop by hop up the tree, each switch updates its forwarding state appropriately. Ultimately, the forwarding state associated with a multicast group or source is removed.

A multicast data sender sends data destined for a multicast group. The designated switch (DR) of the sender takes those data packets, unicast-encapsulates them, and sends them directly to the RP. The RP receives these encapsulated data packets, de-encapsulates them, and forwards them onto the shared tree. The packets then follow the (\*, G) multicast tree state in the switches on the RP tree, being replicated wherever the RP tree branches, and eventually reaching all the receivers for that multicast group. The process of encapsulating data packets to the RP is called registering, and the encapsulation packets are called PIM register packets.

### IPv6 BSR: Configure RP Mapping

PIM switches in a domain must be able to map each multicast group to the correct RP address. The BSR protocol for PIM-SM provides a dynamic, adaptive mechanism to distribute group-to-RP mapping information rapidly throughout a domain. With the IPv6 BSR feature, if an RP becomes unreachable, it will be detected and the mapping tables will be modified so that the unreachable RP is no longer used, and the new tables will be rapidly distributed throughout the domain.

Every PIM-SM multicast group needs to be associated with the IP or IPv6 address of an RP. When a new multicast sender starts sending, its local DR will encapsulate these data packets in a PIM register message and send them to the RP for that multicast group. When a new multicast receiver joins, its local DR will send a PIM join message to the RP for that multicast group. When any PIM switch sends a (\*, G) join message, the PIM switch needs to know which is the next switch toward the RP so that G (Group) can send a message

to that switch. Also, when a PIM switch is forwarding data packets using (\*, G) state, the PIM switch needs to know which is the correct incoming interface for packets destined for G, because it needs to reject any packets that arrive on other interfaces.

A small set of switches from a domain are configured as candidate bootstrap switches (C-BSRs) and a single BSR is selected for that domain. A set of switches within a domain are also configured as candidate RPs (C-RPs); typically, these switches are the same switches that are configured as C-BSRs. Candidate RPs periodically unicast candidate-RP-advertisement (C-RP-Adv) messages to the BSR of that domain, advertising their willingness to be an RP. A C-RP-Adv message includes the address of the advertising C-RP, and an optional list of group addresses and mask length fields, indicating the group prefixes for which the candidacy is advertised. The BSR then includes a set of these C-RPs, along with their corresponding group prefixes, in bootstrap messages (BSMs) it periodically originates. BSMs are distributed hop-by-hop throughout the domain.

Bidirectional BSR support allows bidirectional RPs to be advertised in C-RP messages and bidirectional ranges in the BSM. All switches in a system must be able to use the bidirectional range in the BSM; otherwise, the bidirectional RP feature will not function.

## PIM-Source Specific Multicast

PIM-SSM is the routing protocol that supports the implementation of SSM and is derived from PIM-SM. However, unlike PIM-SM where data from all multicast sources are sent when there is a PIM join, the SSM feature forwards datagram traffic to receivers from only those multicast sources that the receivers have explicitly joined, thus optimizing bandwidth utilization and denying unwanted Internet broadcast traffic. Further, instead of the use of RP and shared trees, SSM uses information found on source addresses for a multicast group. This information is provided by receivers through the source addresses relayed to the last-hop switches by MLD membership reports, resulting in shortest-path trees directly to the sources.

In SSM, delivery of datagrams is based on (S, G) channels. Traffic for one (S, G) channel consists of datagrams with an IPv6 unicast source address S and the multicast group address G as the IPv6 destination address. Systems will receive this traffic by becoming members of the (S, G) channel. Signaling is not required, but receivers must subscribe or unsubscribe to (S, G) channels to receive or not receive traffic from specific sources.

MLD version 2 is required for SSM to operate. MLD allows the host to provide source information. Before SSM can run with MLD, SSM must be supported in the Cisco IOS IPv6 switch, the host where the application is running, and the application itself.

## Routable Address Hello Option

When an IPv6 interior gateway protocol is used to build the unicast routing table, the procedure to detect the upstream switch address assumes the address of a PIM neighbor is always same as the address of the next-hop switch, as long as they refer to the same switch. However, it may not be the case when a switch has multiple addresses on a link.

Two typical situations can lead to this situation for IPv6. The first situation can occur when the unicast routing table is not built by an IPv6 interior gateway protocol such as multicast BGP. The second situation occurs when the address of an RP shares a subnet prefix with downstream switches (note that the RP switch address has to be domain-wide and therefore cannot be a link-local address).

The routable address hello option allows the PIM protocol to avoid such situations by adding a PIM hello message option that includes all the addresses on the interface on which the PIM hello message is advertised. When a PIM switch finds an upstream switch for some address, the result of RPF calculation is compared with the addresses in this option, in addition to the PIM neighbor's address itself. Because this option includes all the possible addresses of a PIM switch on that link, it always includes the RPF calculation result if it refers to the PIM switch supporting this option.



Because of size restrictions on PIM messages and the requirement that a routable address hello option fits within a single PIM hello message, a limit of 16 addresses can be configured on the interface.

## PIM IPv6 Stub Routing

The PIM stub routing feature reduces resource usage by moving routed traffic closer to the end user.

In a network using PIM stub routing, the only allowable route for IPv6 traffic to the user is through a switch that is configured with PIM stub routing. PIM passive interfaces are connected to Layer 2 access domains, such as VLANs, or to interfaces that are connected to other Layer 2 devices. Only directly connected multicast receivers and sources are allowed in the Layer 2 access domains. The PIM passive interfaces do not send or process any received PIM control packets.

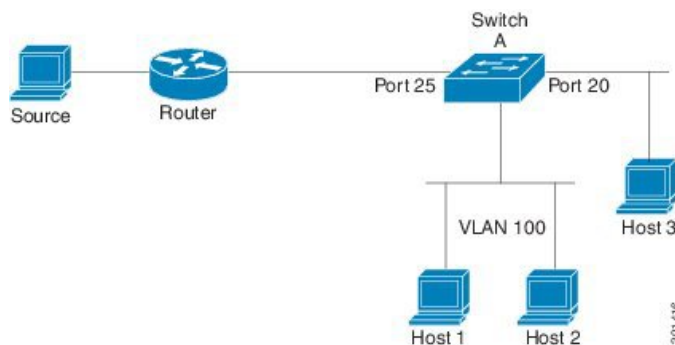
When using PIM stub routing, you should configure the distribution and remote routers to use IPv6 multicast routing and configure only the switch as a PIM stub router. The switch does not route transit traffic between distribution routers. You also need to configure a routed uplink port on the switch. The switch uplink port cannot be used with SVIs.

You must also configure EIGRP stub routing when configuring PIM stub routing on the switch.

The redundant PIM stub router topology is not supported. The redundant topology exists when there is more than one PIM router forwarding multicast traffic to a single access domain. PIM messages are blocked, and the PIM assert and designated router election mechanisms are not supported on the PIM passive interfaces. Only the non-redundant access router topology is supported by the PIM stub feature. By using a non-redundant topology, the PIM passive interface assumes that it is the only interface and designated router on that access domain.

In the figure shown below, Switch A routed uplink port 25 is connected to the router and PIM stub routing is enabled on the VLAN 100 interfaces and on Host 3. This configuration allows the directly connected hosts to receive traffic from multicast source.

**Figure 10: PIM Stub Router Configuration**



## Static Mroutes

IPv6 static mroutes behave much in the same way as IPv4 static mroutes used to influence the RPF check. IPv6 static mroutes share the same database as IPv6 static routes and are implemented by extending static route support for RPF checks. Static mroutes support equal-cost multipath mroutes, and they also support unicast-only static routes.

## MRIB

The Multicast Routing Information Base (MRIB) is a protocol-independent repository of multicast routing entries instantiated by multicast routing protocols (routing clients). Its main function is to provide independence between routing protocols and the Multicast Forwarding Information Base (MFIB). It also acts as a coordination and communication point among its clients.

Routing clients use the services provided by the MRIB to instantiate routing entries and retrieve changes made to routing entries by other clients. Besides routing clients, MRIB also has forwarding clients (MFIB instances) and special clients such as MLD. MFIB retrieves its forwarding entries from MRIB and notifies the MRIB of any events related to packet reception. These notifications can either be explicitly requested by routing clients or spontaneously generated by the MFIB.

Another important function of the MRIB is to allow for the coordination of multiple routing clients in establishing multicast connectivity within the same multicast session. MRIB also allows for the coordination between MLD and routing protocols.

## MFIB

The MFIB is a platform-independent and routing-protocol-independent library for IPv6 software. Its main purpose is to provide a Cisco IOS platform with an interface with which to read the IPv6 multicast forwarding table and notifications when the forwarding table changes. The information provided by the MFIB has clearly defined forwarding semantics and is designed to make it easy for the platform to translate to its specific hardware or software forwarding mechanisms.

When routing or topology changes occur in the network, the IPv6 routing table is updated, and those changes are reflected in the MFIB. The MFIB maintains next-hop address information based on the information in the IPv6 routing table. Because there is a one-to-one correlation between MFIB entries and routing table entries, the MFIB contains all known routes and eliminates the need for route cache maintenance that is associated with switching paths such as fast switching and optimum switching.

## MFIB




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**Note** Distributed MFIB has its significance only in a stacked environment where the Master distributes the MFIB information to the other stack members. In the following section the line cards are nothing but the member switches in the stack.

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MFIB (MFIB) is used to switch multicast IPv6 packets on distributed platforms. MFIB may also contain platform-specific information on replication across line cards. The basic MFIB routines that implement the core of the forwarding logic are common to all forwarding environments.

MFIB implements the following functions:

- Relays data-driven protocol events generated in the line cards to PIM.
- Provides an MFIB platform application program interface (API) to propagate MFIB changes to platform-specific code responsible for programming the hardware acceleration engine. This API also includes entry points to switch a packet in software (necessary if the packet is triggering a data-driven event) and to upload traffic statistics to the software.

The combination of MFIB and MRIB subsystems also allows the switch to have a "customized" copy of the MFIB database in each line card and to transport MFIB-related platform-specific information from the RP to the line cards.

## IPv6 Multicast Process Switching and Fast Switching

A unified MFIB is used to provide both fast switching and process switching support for PIM-SM and PIM-SSM in IPv6 multicast. In process switching, the IOS daemon must examine, rewrite, and forward each packet. The packet is first received and copied into the system memory. The switch then looks up the Layer 3 network address in the routing table. The Layer 2 frame is then rewritten with the next-hop destination address and sent to the outgoing interface. The IOSd also computes the cyclic redundancy check (CRC). This switching method is the least scalable method for switching IPv6 packets.

IPv6 multicast fast switching allows switches to provide better packet forwarding performance than process switching. Information conventionally stored in a route cache is stored in several data structures for IPv6 multicast switching. The data structures provide optimized lookup for efficient packet forwarding.

In IPv6 multicast forwarding, the first packet is fast-switched if the PIM protocol logic allows it. In IPv6 multicast fast switching, the MAC encapsulation header is precomputed. IPv6 multicast fast switching uses the MFIB to make IPv6 destination prefix-based switching decisions. In addition to the MFIB, IPv6 multicast fast switching uses adjacency tables to prepend Layer 2 addressing information. The adjacency table maintains Layer 2 next-hop addresses for all MFIB entries.

The adjacency table is populated as adjacencies are discovered. Each time an adjacency entry is created (such as through ARP), a link-layer header for that adjacent node is precomputed and stored in the adjacency table. Once a route is determined, it points to a next hop and corresponding adjacency entry. It is subsequently used for encapsulation during switching of packets.

A route might have several paths to a destination prefix, such as when a switch is configured for simultaneous load balancing and redundancy. For each resolved path, a pointer is added for the adjacency corresponding to the next-hop interface for that path. This mechanism is used for load balancing across several paths.

## Multiprotocol BGP for the IPv6 Multicast Address Family

The multiprotocol BGP for the IPv6 multicast address family feature provides multicast BGP extensions for IPv6 and supports the same features and functionality as IPv4 BGP. IPv6 enhancements to multicast BGP include support for an IPv6 multicast address family and network layer reachability information (NLRI) and next hop (the next switch in the path to the destination) attributes that use IPv6 addresses.

Multicast BGP is an enhanced BGP that allows the deployment of interdomain IPv6 multicast. Multiprotocol BGP carries routing information for multiple network layer protocol address families; for example, IPv6 address family and for IPv6 multicast routes. The IPv6 multicast address family contains routes used for RPF lookup by the IPv6 PIM protocol, and multicast BGP IPv6 provides for interdomain transport of the same. Users must use multiprotocol BGP for IPv6 multicast when using IPv6 multicast with BGP because the unicast BGP learned routes will not be used for IPv6 multicast.

Multicast BGP functionality is provided through a separate address family context. A subsequent address family identifier (SAFI) provides information about the type of the network layer reachability information that is carried in the attribute. Multiprotocol BGP unicast uses SAFI 1 messages, and multiprotocol BGP multicast uses SAFI 2 messages. SAFI 1 messages indicate that the routes are only usable for IP unicast, but not IP multicast. Because of this functionality, BGP routes in the IPv6 unicast RIB must be ignored in the IPv6 multicast RPF lookup.

A separate BGP routing table is maintained to configure incongruent policies and topologies (forexample, IPv6 unicast and multicast) by using IPv6 multicast RPF lookup. Multicast RPF lookup is very similar to the IP unicast route lookup.

No MRIB is associated with the IPv6 multicast BGP table. However, IPv6 multicast BGP operates on the unicast IPv6 RIB when needed. Multicast BGP does not insert or update routes into the IPv6 unicast RIB.

## Implementing IPv6 Multicast

### Enabling IPv6 Multicast Routing

To enable IPv6 multicast routing, perform this procedure:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b>	Enter global configuration mode.
<b>Step 3</b>	<b>ipv6 multicast-routing</b>  <b>Example:</b>  Device(config)# <b>ipv6 multicast-routing</b>	Enables multicast routing on all IPv6-enabled interfaces and enables multicast forwarding for PIM and MLD on all enabled interfaces of the switch.
<b>Step 4</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

## Customizing and Verifying the MLD Protocol

### Customizing and Verifying MLD on an Interface

To customize and verify MLD on an interface, perform this procedure:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>interface</b> <i>type number</i> <b>Example:</b>  Device(config)# <b>interface</b> <b>GigabitEthernet 1/0/1</b>	Specifies an interface type and number, and places the switch in interface configuration mode.
<b>Step 4</b>	<b>ipv6 mld join-group</b> [ <i>group-address</i> ] [ <b>include</b>   <b>exclude</b> ] [ <i>source-address</i>   <b>source-list</b> [ <i>acl</i> ]] <b>Example:</b>  Device(config-if)# <b>ipv6 mld join-group</b> <b>FF04::10</b>	Configures MLD reporting for a specified group and source.
<b>Step 5</b>	<b>ipv6 mld access-group</b> <i>access-list-name</i> <b>Example:</b>  Device(config-if)# <b>ipv6 access-list</b> <b>acc-grp-1</b>	Allows the user to perform IPv6 multicast receiver access control.
<b>Step 6</b>	<b>ipv6 mld static-group</b> [ <i>group-address</i> ] [ <b>include</b>   <b>exclude</b> ] [ <i>source-address</i>   <b>source-list</b> [ <i>acl</i> ]] <b>Example:</b>  Device(config-if)# <b>ipv6 mld static-group</b> <b>ff04::10 include 100::1</b>	Statically forwards traffic for the multicast group onto a specified interface and cause the interface to behave as if a MLD joiner were present on the interface.
<b>Step 7</b>	<b>ipv6 mld query-max-response-time</b> <i>seconds</i> <b>Example:</b>  Device(config-if)# <b>ipv6 mld</b> <b>query-timeout 130</b>	Configures the timeout value before the switch takes over as the querier for the interface.
<b>Step 8</b>	<b>exit</b> <b>Example:</b>  Device(config-if)# <b>exit</b>	Enter this command twice to exit interface configuration mode and enter privileged EXEC mode.
<b>Step 9</b>	<b>show ipv6 mld groups</b> [ <b>link-local</b> ] [ <i>group-name</i>   <i>group-address</i> ] [ <i>interface-type</i> <i>interface-number</i> ] [ <b>detail</b>   <b>explicit</b> ] <b>Example:</b>  Device# <b>show ipv6 mld groups</b> <b>GigabitEthernet 1/0/1</b>	Displays the multicast groups that are directly connected to the switch and that were learned through MLD.
<b>Step 10</b>	<b>show ipv6 mld groups summary</b> <b>Example:</b>	Displays the number of (*, G) and (S, G) membership reports present in the MLD cache.

	Command or Action	Purpose
	Device# <code>show ipv6 mld groups summary</code>	
<b>Step 11</b>	<b>show ipv6 mld interface</b> [ <i>type number</i> ] <b>Example:</b>  Device# <code>show ipv6 mld interface GigabitEthernet 1/0/1</code>	Displays multicast-related information about an interface.
<b>Step 12</b>	<b>debug ipv6 mld</b> [ <i>group-name</i>   <i>group-address</i>   <i>interface-type</i> ] <b>Example:</b>  Device# <code>debug ipv6 mld</code>	Enables debugging on MLD protocol activity.
<b>Step 13</b>	<b>debug ipv6 mld explicit</b> [ <i>group-name</i>   <i>group-address</i> ] <b>Example:</b>  Device# <code>debug ipv6 mld explicit</code>	Displays information related to the explicit tracking of hosts.
<b>Step 14</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

## Implementing MLD Group Limits

Per-interface and global MLD limits operate independently of each other. Both per-interface and global MLD limits can be configured on the same switch. The number of MLD limits, globally or per interface, is not configured by default; the limits must be configured by the user. A membership report that exceeds either the per-interface or the global state limit is ignored.

### Implementing MLD Group Limits Globally

To implement MLD group limits globally, perform this procedure:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <code>enable</code>	Enables privileged EXEC mode.  Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>ipv6 mld</b> [ <i>vrf vrf-name</i> ] <b>state-limit</b> <i>number</i> <b>Example:</b> Device(config)# <b>ipv6 mld state-limit 300</b>	Limits the number of MLD states globally.
<b>Step 4</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

### Implementing MLD Group Limits per Interface

To implement MLD group limits per interface, perform this procedure:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface type</b> <i>number</i> <b>Example:</b> Device(config)# <b>interface GigabitEthernet 1/0/1</b>	Specifies an interface type and number, and places the switch in interface configuration mode.
<b>Step 4</b>	<b>ipv6 mld limit</b> <i>number</i> [ <b>except</b> ] <i>access-list</i> <b>Example:</b> Device(config-if)# <b>ipv6 mld limit 100</b>	Limits the number of MLD states on a per-interface basis.
<b>Step 5</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

### Configuring Explicit Tracking of Receivers to Track Host Behavior

The explicit tracking feature allows a switch to track the behavior of the hosts within its IPv6 network and enables the fast leave mechanism to be used with MLD version 2 host reports.

To configuring explicit tracking of receivers to track host behavior, perform this procedure:

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b>	Enter global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>type number</i> <b>Example:</b> Device(config)# <b>interface</b> GigabitEthernet 1/0/1	Specifies an interface type and number, and places the switch in interface configuration mode.
<b>Step 4</b>	<b>ipv6 mld explicit-tracking</b> <i>access-list-name</i> <b>Example:</b> Device(config-if)# <b>ipv6 mld</b> <b>explicit-tracking list1</b>	Enables explicit tracking of hosts.
<b>Step 5</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

**Resetting the MLD Traffic Counters**

To reset the MLD traffic counters, perform this procedure:

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>clear ipv6 mld traffic</b> <b>Example:</b> Device# <b>clear ipv6 mld traffic</b>	Resets all MLD traffic counters.
<b>Step 4</b>	<b>show ipv6 mld traffic</b> <b>Example:</b>	Displays the MLD traffic counters.



	Command or Action	Purpose
	Device# <code>show ipv6 mld traffic</code>	
<b>Step 5</b>	<code>copy running-config startup-config</code>	(Optional) Save your entries in the configuration file.

## Clearing the MLD Interface Counters

To clearing the MLD interface counters, perform this procedure

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>enable</code> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<code>configure terminal</code> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<code>clear ipv6 mld counters interface-type</code> <b>Example:</b> Device# <code>clear ipv6 mld counters Ethernet1/0</code>	Clears the MLD interface counters.
<b>Step 4</b>	<code>copy running-config startup-config</code>	(Optional) Save your entries in the configuration file.

## Configuring PIM

This section explains how to configure PIM.

### Configuring PIM-SM and Displaying PIM-SM Information for a Group Range

To configuring PIM-SM and view PIM-SM information for a group range, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>enable</code> <b>Example:</b>	Enables privileged EXEC mode. Enter your password if prompted.

	Command or Action	Purpose
	Device> <b>enable</b>	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 pim rp-address</b> <i>ipv6-address[group-access-list]</i> <b>Example:</b> Device (config)# <b>ipv6 pim rp-address</b> <b>2001:DB8::01:800:200E:8C6C acc-grp-1</b>	Configures the address of a PIM RP for a particular group range.
<b>Step 4</b>	<b>exit</b> <b>Example:</b> Device (config)# <b>exit</b>	Exits global configuration mode, and returns the switch to privileged EXEC mode.
<b>Step 5</b>	<b>show ipv6 pim interface</b> [state-on] [state-off] [type-number] <b>Example:</b> Device# <b>show ipv6 pim interface</b>	Displays information about interfaces configured for PIM.
<b>Step 6</b>	<b>show ipv6 pim group-map</b> [group-name   group-address] [group-range   group-mask] [info-source {bsr   default   embedded-rp   static}] <b>Example:</b> Device# <b>show ipv6 pim group-map</b>	Displays an IPv6 multicast group mapping table.
<b>Step 7</b>	<b>show ipv6 pim neighbor</b> [detail] [interface-type interface-number   count] <b>Example:</b> Device# <b>show ipv6 pim neighbor</b>	Displays the PIM neighbors discovered by the Cisco IOS software.
<b>Step 8</b>	<b>show ipv6 pim range-list</b> [config] [rp-address   rp-name] <b>Example:</b> Device# <b>show ipv6 pim range-list</b>	Displays information about IPv6 multicast range lists.

	Command or Action	Purpose
<b>Step 9</b>	<b>show ipv6 pim tunnel</b> [ <i>interface-type</i> <i>interface-number</i> ]  <b>Example:</b>  Device# <b>show ipv6 pim tunnel</b>	Displays information about the PIM register encapsulation and de-encapsulation tunnels on an interface.
<b>Step 10</b>	<b>debug ipv6 pim</b> [ <i>group-name</i>   <i>group-address</i>   <i>interface interface-type</i>   <i>bsr</i>   <i>group</i>   <i>mvpn</i>   <i>neighbor</i> ]  <b>Example:</b>  Device# <b>debug ipv6 pim</b>	Enables debugging on PIM protocol activity.
<b>Step 11</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

## Configuring PIM Options

To configure PIM options, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 pim spt-threshold infinity</b> [ <i>group-list</i> <i>access-list-name</i> ]  <b>Example:</b>  Device (config)# <b>ipv6 pim spt-threshold</b> <b>infinity group-list acc-grp-1</b>	Configures when a PIM leaf switch joins the SPT for the specified groups.
<b>Step 4</b>	<b>ipv6 pim accept-register</b> { <i>list access-list</i>   <i>route-map map-name</i> }  <b>Example:</b>  Device (config)# <b>ipv6 pim accept-register</b> <b>route-map reg-filter</b>	Accepts or rejects registers at the RP.

	Command or Action	Purpose
<b>Step 5</b>	<b>interface</b> <i>type number</i> <b>Example:</b>  Device (config)# <b>interface</b> <b>GigabitEthernet 1/0/1</b>	Specifies an interface type and number, and places the switch in interface configuration mode.
<b>Step 6</b>	<b>ipv6 pim dr-priority</b> <i>value</i> <b>Example:</b>  Device (config-if)# <b>ipv6 pim dr-priority</b> <b>3</b>	Configures the DR priority on a PIM switch.
<b>Step 7</b>	<b>ipv6 pim hello-interval</b> <i>seconds</i> <b>Example:</b>  Device (config-if)# <b>ipv6 pim</b> <b>hello-interval 45</b>	Configures the frequency of PIM hello messages on an interface.
<b>Step 8</b>	<b>ipv6 pim join-prune-interval</b> <i>seconds</i> <b>Example:</b>  Device (config-if)# <b>ipv6 pim</b> <b>join-prune-interval 75</b>	Configures periodic join and prune announcement intervals for a specified interface.
<b>Step 9</b>	<b>exit</b> <b>Example:</b>  Device (config-if)# <b>exit</b>	Enter this command twice to exit interface configuration mode and enter privileged EXEC mode.
<b>Step 10</b>	<b>ipv6 pim join-prune statistic</b> [ <i>interface-type</i> ] <b>Example:</b>  Device (config-if)# <b>show ipv6 pim</b> <b>join-prune statistic</b>	Displays the average join-prune aggregation for the most recently aggregated packets for each interface.
<b>Step 11</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

## Resetting the PIM Traffic Counters

If PIM malfunctions or in order to verify that the expected number of PIM packets are received and sent, the user can clear PIM traffic counters. Once the traffic counters are cleared, the user can enter the `show ipv6 pim traffic` command to verify that PIM is functioning correctly and that PIM packets are being received and sent correctly.

To resetting the PIM traffic counters, perform this procedure:

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <code>enable</code>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>clear ipv6 pim traffic</b> <b>Example:</b>  Device# <code>clear ipv6 pim traffic</code>	Resets the PIM traffic counters.
<b>Step 4</b>	<b>show ipv6 pim traffic</b> <b>Example:</b>  Device# <code>show ipv6 pim traffic</code>	Displays the PIM traffic counters.
<b>Step 5</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

**Clearing the PIM Topology Table to Reset the MRIB Connection**

No configuration is necessary to use the MRIB. However, users may in certain situations want to clear the PIM topology table in order to reset the MRIB connection and verify MRIB information.

To clear the PIM topology table to reset the MRIB connection, perform this procedure:

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <code>enable</code>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<p><b>clear ipv6 pim topology</b> [<i>group-name</i>   <i>group-address</i>]</p> <p><b>Example:</b></p> <pre>Device# clear ipv6 pim topology FF04::10</pre>	Clears the PIM topology table.
<b>Step 4</b>	<p><b>show ipv6 mrib client</b> [<i>filter</i>] [<i>name</i> {<i>client-name</i>   <i>client-name</i> : <i>client-id</i>}]</p> <p><b>Example:</b></p> <pre>Device# show ipv6 mrib client</pre>	Displays multicast-related information about an interface.
<b>Step 5</b>	<p><b>show ipv6 mrib route</b> {<i>link-local</i>   <i>summary</i>   [<i>sourceaddress-or-name</i>   *] [<i>groupname-or-address</i> [<i>prefix-length</i>]]]</p> <p><b>Example:</b></p> <pre>Device# show ipv6 mrib route</pre>	Displays the MRIB route information.
<b>Step 6</b>	<p><b>show ipv6 pim topology</b> [<i>groupname-or-address</i> [<i>sourceaddress-or-name</i>]   <i>link-local</i>   <i>route-count</i> [<i>detail</i>]]</p> <p><b>Example:</b></p> <pre>Device# show ipv6 pim topology</pre>	Displays PIM topology table information for a specific group or all groups.
<b>Step 7</b>	<p><b>debug ipv6 mrib client</b></p> <p><b>Example:</b></p> <pre>Device# debug ipv6 mrib client</pre>	Enables debugging on MRIB client management activity.
<b>Step 8</b>	<p><b>debug ipv6 mrib io</b></p> <p><b>Example:</b></p> <pre>Device# debug ipv6 mrib io</pre>	Enables debugging on MRIB I/O events.
<b>Step 9</b>	<p><b>debug ipv6 mrib proxy</b></p> <p><b>Example:</b></p> <pre>Device# debug ipv6 mrib proxy</pre>	Enables debugging on MRIB proxy activity between the switch processor and line cards on distributed switch platforms.
<b>Step 10</b>	<p><b>debug ipv6 mrib route</b> [<i>group-name</i>   <i>group-address</i>]</p> <p><b>Example:</b></p> <pre>Device# debug ipv6 mrib route</pre>	Displays information about MRIB routing entry-related activity.

	Command or Action	Purpose
<b>Step 11</b>	<b>debug ipv6 mrib table</b> <b>Example:</b> Device# <code>debug ipv6 mrib table</code>	Enables debugging on MRIB table management activity.
<b>Step 12</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

## Configuring PIM IPv6 Stub Routing

The PIM Stub routing feature supports multicast routing between the distribution layer and the access layer. It supports two types of PIM interfaces, uplink PIM interfaces, and PIM passive interfaces. A routed interface configured with the PIM passive mode does not pass or forward PIM control traffic, it only passes and forwards MLD traffic.

### PIM IPv6 Stub Routing Configuration Guidelines

- Before configuring PIM stub routing, you must have IPv6 multicast routing configured on both the stub router and the central router. You must also have PIM mode (sparse-mode) configured on the uplink interface of the stub router.
- The PIM stub router does not route the transit traffic between the distribution routers. Unicast (EIGRP) stub routing enforces this behavior. You must configure unicast stub routing to assist the PIM stub router behavior. For more information, see the *EIGRP Stub Routing* section.
- Only directly connected multicast (MLD) receivers and sources are allowed in the Layer 2 access domains. The PIM protocol is not supported in access domains.
- The redundant PIM stub router topology is not supported.

### Default IPv6 PIM Routing Configuration

This table displays the default IPv6 PIM routing configuration for the Device.

**Table 23: Default Multicast Routing Configuration**

Feature	Default Setting
Multicast routing	Disabled on all interfaces.
PIM version	Version 2.
PIM mode	No mode is defined.
PIM stub routing	None configured.
PIM RP address	None configured.
PIM domain border	Disabled.
PIM multicast boundary	None.
Candidate BSRs	Disabled.

Feature	Default Setting
Candidate RPs	Disabled.
Shortest-path tree threshold rate	0 kb/s.
PIM router query message interval	30 seconds.

## Enabling IPv6 PIM Stub Routing

To enable IPv6 PIM stub routing, perform this procedure:

### Before you begin

PIM stub routing is disabled in IPv6 by default.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 multicast pim-passive-enable</b> <b>Example:</b> Device(config-if)# <b>ipv6 multicast pim-passive-enable</b>	Enables IPv6 Multicast PIM routing on the switch.
<b>Step 4</b>	<b>interface interface-id</b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 9/0/6</b>	Specifies the interface on which you want to enable PIM stub routing, and enters interface configuration mode. The specified interface must be one of the following: <ul style="list-style-type: none"> <li>• A routed port—A physical port that has been configured as a Layer 3 port by entering the <b>no switchport</b> interface configuration command. You will also need to enable IP PIM sparse mode on the interface, and join the interface as a statically connected member to an MLD static group.</li> </ul>



	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>An SVI—A VLAN interface created by using the <b>interface vlan</b> <i>vlan-id</i> global configuration command. You will also need to enable IP PIM sparse mode on the VLAN, join the VLAN as a statically connected member to an MLD static group, and then enable MLD snooping on the VLAN, the MLD static group, and physical interface.</li> </ul> <p>These interfaces must have IPv6 addresses assigned to them.</p>
<b>Step 5</b>	<b>ipv6 pim</b> <b>Example:</b> <pre>Device(config-if)# ipv6 pim</pre>	Enables the PIM on the interface.
<b>Step 6</b>	<b>ipv6 pim {bsr}   {dr-priority   value}   {hello-interval   seconds}   {join-prune-interval   seconds}   {passive}</b> <b>Example:</b> <pre>Device(config-if)# ipv6 pim bsr dr-priority hello-interval join-prune-interval passive</pre>	<p>Configures the various PIM stub features on the interface.</p> <p>Enter <b>bsr</b> to configure BSR on a PIM switch</p> <p>Enter <b>dr-priority</b> to configure the DR priority on a PIM switch.</p> <p>Enter <b>hello-interval</b> to configure the frequency of PIM hello messages on an interface.</p> <p>Enter <b>join-prune-interval</b> to configure periodic join and prune announcement intervals for a specified interface.</p> <p>Enter <b>passive</b> to configure the PIM in the passive mode.</p>
<b>Step 7</b>	<b>end</b> <b>Example:</b> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.

## Monitoring IPv6 PIM Stub Routing

Table 24: PIM Stub Configuration show Commands

Command	Purpose
<b>show ipv6 pim interface</b> <pre>Device# show ipv6 pim interface</pre>	Displays the PIM stub that is enabled on each interface.

Command	Purpose
<b>show ipv6 mld groups</b>  Device# <b>show ipv6 mld groups</b>	Displays the interested clients that have joined the specific multicast source group.
<b>show ipv6 mroute</b>  Device# <b>show ipv6 mroute</b>	Verifies that the multicast stream forwards from the source to the interested clients.

## Configuring a BSR

The tasks included here are described below.

### Configuring a BSR and Verifying BSR Information

To configure and verify BSR Information, perform this procedure:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 pim bsr candidate bsr</b> <i>ipv6-address[hash-mask-length] [priority</i> <i>priority-value]</i>  <b>Example:</b>  Device(config)# <b>ipv6 pim bsr candidate</b> <b>bsr 2001:DB8:3000:3000::42 124 priority</b> <b>10</b>	Configures a switch to be a candidate BSR.
<b>Step 4</b>	<b>interface type number</b>  <b>Example:</b>  Device(config)# <b>interface GigabitEthernet</b> <b>1/0/1</b>	Specifies an interface type and number, and places the switch in interface configuration mode.

	Command or Action	Purpose
<b>Step 5</b>	<b>ipv6 pim bsr border</b> <b>Example:</b>  Device(config-if)# <b>ipv6 pim bsr border</b>	Specifies an interface type and number, and places the switch in interface configuration mode.
<b>Step 6</b>	<b>exit</b> <b>Example:</b>  Device(config-if)# <b>exit</b>	Enter this command twice to exit interface configuration mode and enter privileged EXEC mode.
<b>Step 7</b>	<b>show ipv6 pim bsr {election   rp-cache   candidate-rp}</b> <b>Example:</b>  Device(config-if)# <b>show ipv6 pim bsr election</b>	Displays information related to PIM BSR protocol processing.
<b>Step 8</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

## Sending PIM RP Advertisements to the BSR

To sending PIM RP advertisements to the BSR, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 pim bsr candidate rp <i>ipv6-address</i> [group-list <i>access-list-name</i>] [priority <i>priority-value</i>] [interval seconds]</b> <b>Example:</b>  Device(config)# <b>ipv6 pim bsr candidate rp 2001:DB8:3000:3000::42 priority 0</b>	Sends PIM RP advertisements to the BSR.

	Command or Action	Purpose
<b>Step 4</b>	<b>interface</b> <i>type number</i> <b>Example:</b>  Device(config)# <b>interface</b> GigabitEthernet 1/0/1	Specifies an interface type and number, and places the switch in interface configuration mode.
<b>Step 5</b>	<b>ipv6 pim bsr border</b> <b>Example:</b>  Device(config-if)# <b>ipv6 pim bsr border</b>	Configures a border for all BSMs of any scope on a specified interface.
<b>Step 6</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

## Configuring BSR for Use Within Scoped Zones

To configure BSR for use within scoped zones, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 pim bsr candidate rp</b> <i>ipv6-address</i> <i>[hash-mask-length]</i> [ <b>priority</b> <i>priority-value</i> ] <b>Example:</b>  Device(config)# <b>ipv6 pim bsr candidate</b> <b>bsr</b> 2001:DB8:1:1:4	Configures a switch to be a candidate BSR.
<b>Step 4</b>	<b>ipv6 pim bsr candidate rp</b> <i>ipv6-address</i> <b>[group-list</b> <i>access-list-name</i> <b>] [priority</b> <i>priority-value</i> <b>] [interval</b> <i>seconds</i> <b>]</b> <b>Example:</b>  Device(config)# <b>ipv6 pim bsr candidate</b> <b>rp</b> 2001:DB8:1:1:1 <b>group-list</b> list <b>scope</b> 6	Configures the candidate RP to send PIM RP advertisements to the BSR.

	Command or Action	Purpose
<b>Step 5</b>	<b>interface</b> <i>type number</i> <b>Example:</b>  Device(config-if)# <b>interface</b> <b>GigabitEthernet 1/0/1</b>	Specifies an interface type and number, and places the switch in interface configuration mode.
<b>Step 6</b>	<b>ipv6 multicast boundary scope</b> <i>scope-value</i> <b>Example:</b>  Device(config-if)# <b>ipv6 multicast</b> <b>boundary scope 6</b>	Configures a multicast boundary on the interface for a specified scope.
<b>Step 7</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

## Configuring BSR Switches to Announce Scope-to-RP Mappings

IPv6 BSR switches can be statically configured to announce scope-to-RP mappings directly instead of learning them from candidate-RP messages. A user might want to configure a BSR switch to announce scope-to-RP mappings so that an RP that does not support BSR is imported into the BSR. Enabling this feature also allows an RP positioned outside the enterprise's BSR domain to be learned by the known remote RP on the local candidate BSR switch.

To configure BSR switches to announce Scope-to-RP mappings, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 pim bsr announced rp</b> <i>ipv6-address</i> <b>[group-list</b> <i>access-list-name</i> <b>]</b> <b>[priority</b> <i>priority-value</i> <b>]</b> <b>Example:</b>  Device(config)# <b>ipv6 pim bsr announced</b> <b>rp 2001:DB8:3000:3000::42 priority 0</b>	Announces scope-to-RP mappings directly from the BSR for the specified candidate RP.

	Command or Action	Purpose
<b>Step 4</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

## Configuring SSM Mapping

When the SSM mapping feature is enabled, DNS-based SSM mapping is automatically enabled, which means that the switch will look up the source of a multicast MLD version 1 report from a DNS server.

You can use either DNS-based or static SSM mapping, depending on your switch configuration. If you choose to use static SSM mapping, you can configure multiple static SSM mappings. If multiple static SSM mappings are configured, the source addresses of all matching access lists will be used.



**Note** To use DNS-based SSM mapping, the switch needs to find at least one correctly configured DNS server, to which the switch may be directly attached.

To configuring SSM mapping, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 mld ssm-map enable</b> <b>Example:</b>  Device(config)# <b>ipv6 mld ssm-map enable</b>	Enables the SSM mapping feature for groups in the configured SSM range.
<b>Step 4</b>	<b>no ipv6 mld ssm-map query dns</b> <b>Example:</b>  Device(config)# <b>no ipv6 mld ssm-map query dns</b>	Disables DNS-based SSM mapping.
<b>Step 5</b>	<b>ipv6 mld ssm-map static access-list source-address</b> <b>Example:</b>	Configures static SSM mappings.

	Command or Action	Purpose
	<code>Device(config-if)# ipv6 mld ssm-map static SSM_MAP_ACL_2 2001:DB8:1::1</code>	
<b>Step 6</b>	<b>exit</b> <b>Example:</b> <code>Device(config-if)# exit</code>	Exits global configuration mode, and returns the switch to privileged EXEC mode.
<b>Step 7</b>	<b>show ipv6 mld ssm-map</b> <i>[source-address]</i> <b>Example:</b> <code>Device(config-if)# show ipv6 mld ssm-map</code>	Displays SSM mapping information.
<b>Step 8</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

## Configuring Static Mroutes

Static multicast routes (mroutes) in IPv6 can be implemented as an extension of IPv6 static routes. You can configure your switch to use a static route for unicast routing only, to use a static multicast route for multicast RPF selection only, or to use a static route for both unicast routing and multicast RPF selection.

To configure static mroutes, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <code>Device&gt; enable</code>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <code>Device# configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 route</b> <i>{ipv6-prefix / prefix-length ipv6-address   interface-type interface-number ipv6-address}</i> <i>[administrative-distance]</i> <i>[administrative-multicast-distance   unicast   multicast]</i> <i>[tag tag]</i> <b>Example:</b>	Establishes static IPv6 routes. The example shows a static route used for both unicast routing and multicast RPF selection.

	Command or Action	Purpose
	Device(config)# <b>ipv6 route 2001:DB8::/64 6::6 100</b>	
<b>Step 4</b>	<b>exit</b> <b>Example:</b>  Device# <b>exit</b>	Exits global configuration mode, and returns the switch to privileged EXEC mode.
<b>Step 5</b>	<b>show ipv6 mroute</b> [link-local   [group-name   group-address [source-address   source-name]] [summary] [count] <b>Example:</b>  Device# <b>show ipv6 mroute ff07::1</b>	Displays the contents of the IPv6 multicast routing table.
<b>Step 6</b>	<b>show ipv6 mroute</b> [link-local   group-name   group-address] <b>active</b> [kpbs] <b>Example:</b>  Device(config-if)# <b>show ipv6 mroute active</b>	Displays the active multicast streams on the switch.
<b>Step 7</b>	<b>show ipv6 rpf</b> [ipv6-prefix] <b>Example:</b>  Device(config-if)# <b>show ipv6 rpf 2001::1:1:2</b>	Checks RPF information for a given unicast host address and prefix.
<b>Step 8</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

## Using MFIB in IPv6 Multicast

Multicast forwarding is automatically enabled when IPv6 multicast routing is enabled.

### Verifying MFIB Operation in IPv6 Multicast

To verify MFIB operation in IPv6 multicast

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  Enter your password if prompted.



	Command or Action	Purpose
<b>Step 2</b>	<b>show ipv6 mfib</b> [ <b>linkscope</b>   <b>verbose</b>   <i>group-address-name</i>   <i>ipv6-prefix / prefix-length</i>   <i>source-address-name</i>   <b>count</b>   <b>interface</b>   <b>status</b>   <b>summary</b> ]  <b>Example:</b>  Device# <b>show ipv6 mfib</b>	Displays the forwarding entries and interfaces in the IPv6 MFIB.
<b>Step 3</b>	<b>show ipv6 mfib</b> [ <b>all</b>   <b>linkscope</b>   <b>group-name</b>   <b>group-address</b> [ <b>source-name</b>   <b>source-address</b> ]]   <b>count</b>  <b>Example:</b>  Device# <b>show ipv6 mfib ff07::1</b>	Displays the contents of the IPv6 multicast routing table.
<b>Step 4</b>	<b>show ipv6 mfib interface</b>  <b>Example:</b>  Device# <b>show ipv6 mfib interface</b>	Displays information about IPv6 multicast-enabled interfaces and their forwarding status.
<b>Step 5</b>	<b>show ipv6 mfib status</b>  <b>Example:</b>  Device# <b>show ipv6 mfib status</b>	Displays general MFIB configuration and operational status.
<b>Step 6</b>	<b>show ipv6 mfib summary</b>  <b>Example:</b>  Device# <b>show ipv6 mfib summary</b>	Displays summary information about the number of IPv6 MFIB entries and interfaces.
<b>Step 7</b>	<b>debug ipv6 mfib</b> [ <i>group-name</i>   <i>group-address</i> ] [ <b>adjacency</b>   <b>db</b>   <b>fs</b>   <b>init</b>   <b>interface</b>   <b>mrrib</b> [ <b>detail</b> ]   <b>nat</b>   <b>pak</b>   <b>platform</b>   <b>ppr</b>   <b>ps</b>   <b>signal</b>   <b>table</b> ]  <b>Example:</b>  Device# <b>debug ipv6 mfib FF04::10 pak</b>	Enables debugging output on the IPv6 MFIB.

## Resetting MFIB Traffic Counters

To reset MFIB traffic counters, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>	Enables privileged EXEC mode.

	Command or Action	Purpose
	<b>Example:</b>  Device> <b>enable</b>	Enter your password if prompted.
<b>Step 2</b>	<b>clear ipv6 mfib counters</b> [ <i>group-name</i>   <b>group-address</b> [ <i>source-address</i>   <i>source-name</i> ]]  <b>Example:</b>  Device# <b>clear ipv6 mfib counters FF04::10</b>	Resets all active MFIB traffic counters.



## CHAPTER 17

# IPv6 Client IP Address Learning

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## Prerequisites for IPv6 Client Address Learning

Before configuring IPv6 client address learning, configure the wireless clients to support IPv6.

## Information About IPv6 Client Address Learning

Client Address Learning is configured on device to learn the wireless client's IPv4 and IPv6 address and clients transition state maintained by the device on an association, re-association, de-authentication and timeout.

There are three ways for IPv6 client to acquire IPv6 addresses:

- Stateless Address Auto-Configuration (SLACC)

- Stateful DHCPv6
- Static Configuration

For all of these methods, the IPv6 client always sends neighbor solicitation DAD (Duplicate Address Detection) request to ensure there is no duplicate IP address on the network. The device snoops the client's NDP and DHCPv6 packets to learn about its client IP addresses.

## SLAAC Address Assignment

The most common method for IPv6 client address assignment is Stateless Address Auto-Configuration (SLAAC). SLAAC provides simple plug-and-play connectivity where clients self-assign an address based on the IPv6 prefix. This process is achieved

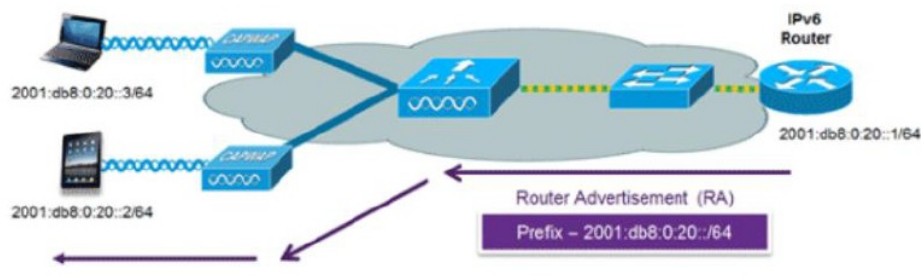
Stateless Address Auto-Configuration (SLAAC) is configured as follows:

- Host sends a router solicitation message.
- Hosts wait for a Router Advertisement message.
- Hosts take the first 64 bits of the IPv6 prefix from the Router Advertisement message and combine it with the 64 bit EUI-64 address (in the case of ethernet, this is created from the MAC Address) to create a global unicast message. The host also uses the source IP address, in the IP header, of the Router Advertisement message, as its default gateway.
- Duplicate Address Detection is performed by IPv6 clients in order to ensure that random addresses that are picked do not collide with other clients.
- The choice of algorithm is up to the client and is often configurable.

The last 64 bits of the IP v6 address can be learned based on the following 2 algorithms:

- EUI-64 which is based on the MAC address of the interface, or
- Private addresses that are randomly generated.

**Figure 11: SLAAC Address Assignment**



The following Cisco IOS configuration commands from a Cisco-capable IPv6 router are used to enable SLAAC addressing and router advertisements:

```

ipv6 unicast-routing
interface Vlan20
description IPv6-SLAAC
ip address 192.168.20.1 255.255.255.0
ipv6 address FE80:DB8:0:20::1 linklocal

```

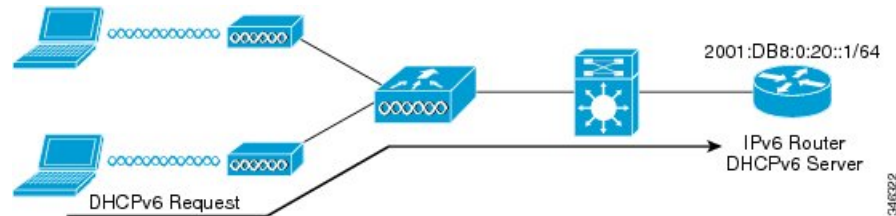
```

ipv6 address 2001:DB8:0:20::1/64
ipv6 enable
end

```

## Stateful DHCPv6 Address Assignment

Figure 12: Stateful DHCPv6 Address Assignment



The use of DHCPv6 is not required for IPv6 client connectivity if SLAAC is already deployed. There are two modes of operation for DHCPv6 called Stateless and Stateful.

The DHCPv6 Stateless mode is used to provide clients with additional network information that is not available in the router advertisement, but not an IPv6 address as this is already provided by SLAAC. This information can include the DNS domain name, DNS server(s), and other DHCP vendor-specific options. This interface configuration is for a Cisco IOS IPv6 router implementing stateless DHCPv6 with SLAAC enabled:

```

ipv6 unicast-routing
ipv6 dhcp pool IPV6_DHCPPPOOL
address prefix 2001:db8:5:10::/64
domain-name cisco.com
dns-server 2001:db8:6:6::1
interface Vlan20
description IPv6-DHCP-Stateless
ip address 192.168.20.1 255.255.255.0
ipv6 nd other-config-flag
ipv6 dhcp server IPV6_DHCPPPOOL
ipv6 address 2001:DB8:0:20::1/64
end

```

The DHCPv6 Stateful option, also known as managed mode, operates similarly to DHCPv4 in that it assigns unique addresses to each client instead of the client generating the last 64 bits of the address as in SLAAC. This interface configuration is for a Cisco IOS IPv6 router implementing stateful DHCPv6 on a local Device:

```

ipv6 unicast-routing
ipv6 dhcp pool IPV6_DHCPPPOOL
address prefix 2001:db8:5:10::/64
domain-name cisco.com
dns-server 2001:db8:6:6::1
interface Vlan20
description IPv6-DHCP-Stateful
ip address 192.168.20.1 255.255.255.0
ipv6 address 2001:DB8:0:20::1/64
ipv6 nd prefix 2001:DB8:0:20::/64 no-advertise
ipv6 nd managed-config-flag
ipv6 nd other-config-flag
ipv6 dhcp server IPV6_DHCPPPOOL
end

```

This interface configuration is for a Cisco IOS IPv6 router implementing stateful DHCPv6 on an external DHCP server:

```

ipv6 unicast-routing
domain-name cisco.com

```

```

dns-server 2001:db8:6:6::1
interface Vlan20
description IPv6-DHCP-Stateful
ip address 192.168.20.1 255.255.255.0
ipv6 address 2001:DB8:0:20::1/64
ipv6 nd prefix 2001:DB8:0:20::/64 no-advertise
ipv6 nd managed-config-flag
ipv6 nd other-config-flag
ipv6 dhcp_relay destination 2001:DB8:0:20::2
end

```

## Static IP Address Assignment

Statically configured address on a client.

## Router Solicitation

A Router Solicitation message is issued by a host controller to facilitate local routers to transmit Router Advertisement from which it can obtain information about local routing or perform Stateless Auto-configuration. Router Advertisements are transmitted periodically and the host prompts with an immediate Router Advertisement using a Router Solicitation such as - when it boots or following a restart operation.

## Router Advertisement

A Router Advertisement message is issued periodically by a router or in response to a Router Solicitation message from a host. The information contained in these messages is used by hosts to perform Stateless Auto-configuration and to modify its routing table.

## Neighbor Discovery

IPv6 Neighbor Discovery is a set of messages and processes that determine relationships between neighboring nodes. Neighbor Discovery replaces ARP, ICMP Router Discovery, and ICMP Redirect used in IPv4.

IPv6 Neighbor Discovery inspection analyzes neighbor discovery messages in order to build a trusted binding table database, and IPv6 neighbor discovery packets that do not comply are dropped. The neighbor binding table in the switch tracks each IPv6 address and its associated MAC address. Clients are expired from the table according to Neighbor Binding timers.

## Neighbor Discovery Suppression

The IPv6 addresses of wireless clients are cached by the device. When the device receives an NS multicast looking for an IPv6 address, and if the target address is known to the device and belongs to one of its clients, the device will reply with an NA message on behalf of the client. The result of this process generates the equivalent of the Address Resolution Protocol (ARP) table of IPv4 but is more efficient - uses generally fewer messages.




---

**Note** The device acts like proxy and respond with NA, only when the **ipv6 nd suppress** command is configured

---

If the device does not have the IPv6 address of a wireless client, the device will not respond with NA and forward the NS packet to the wireless side. To resolve this, an NS Multicast Forwarding knob is provided. If this knob is enabled, the device gets the NS packet for the IPv6 address that it does not have (cache miss) and forwards it to the wireless side. This packet reaches the intended wireless client and the client replies with NA.

This cache miss scenario occurs rarely, and only very few clients which do not implement complete IPv6 stack may not advertise their IPv6 address during NDP.

## RA Guard

IPv6 clients configure IPv6 addresses and populate their router tables based on IPv6 router advertisement (RA) packets. The RA guard feature is similar to the RA guard feature of wired networks. RA guard increases the security of the IPv6 network by dropping the unwanted or rogue RA packets that come from wireless clients. If this feature is not configured, malicious IPv6 wireless clients announce themselves as the router for the network often with high priority, which would take higher precedence over legitimate IPv6 routers.

RA-Guard also examines the incoming RA's and decides whether to switch or block them based solely on information found in the message or in the switch configuration. The information available in the frames received is useful for RA validation:

- Port on which the frame is received
- IPv6 source address
- Prefix list

The following configuration information created on the switch is available to RA-Guard to validate against the information found in the received RA frame:

- Trusted/Untrusted ports for receiving RA-guard messages
- Trusted/Untrusted IPv6 source addresses of RA-sender
- Trusted/Untrusted Prefix list and Prefix ranges
- Router Preference

RA guard occurs at the device. You can configure the device to drop RA messages at the device. All IPv6 RA messages are dropped, which protects other wireless clients and upstream wired network from malicious IPv6 clients.

```
//Create a policy for RA Guard//
ipv6 nd rguard policy rguard-router
trusted-port
device-role router

//Applying the RA Guard Policy on port/interface//
interface tengigabitethernet1/0/1 (Katana)
interface gigabitethernet1/0/1 (Edison)

ipv6 nd rguard attach-policy rguard-router
```

## RA Throttling

RA throttling allows the controller to enforce limits to RA packets headed toward the wireless network. By enabling RA throttling, routers that send many RA packets can be trimmed to a minimum frequency that will

still maintain an IPv6 client connectivity. If a client sends an RS packet, an RA is sent back to the client. This RA is allowed through the controller and unicasted to the client. This process ensures that the new clients or roaming clients are not affected by the RA throttling.

## Configuring IPv6 Unicast

IPv6 unicasting must always be enabled on the switch and the controller. IPv6 unicast routing is disabled.

To configure IPv6 unicast, perform this procedure:

### Before you begin

To enable the forwarding of IPv6 unicast datagrams, use the **ipv6 unicast-routing** command in global configuration mode. To disable the forwarding of IPv6 unicast datagrams, use the **no** form of this command.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 unicast routing</b> <b>Example:</b> Device(config)# <b>ipv6 unicast routing</b>	enable the forwarding of IPv6 unicast datagrams

## Configuring RA Guard Policy

Configure RA Guard policy on the device to add IPv6 client addresses and populate the router table based on IPv6 router advertisement packets.

To configuring RA guard policy, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>	Enables privileged EXEC mode. Enter your password if prompted.



	Command or Action	Purpose
	Device> <b>enable</b>	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 nd raguard policy raguard-router</b> <b>Example:</b> Device(config)# <b>ipv6 nd raguard policy raguard-router</b>	Defines the RA guard policy name and enters RA guard policy configuration mode.
<b>Step 4</b>	<b>trustedport</b> <b>Example:</b> Device(config-ra-guard)# <b>trustedport</b>	(Optional) Specifies that this policy is being applied to trusted ports.
<b>Step 5</b>	<b>device-role router</b> <b>Example:</b> Device(config-ra-guard)# <b>device-role router</b>	Specifies the role of the device attached to the port.
<b>Step 6</b>	<b>exit</b> <b>Example:</b> Device(config-ra-guard)# <b>exit</b>	Exits RA guard policy configuration mode and returns to global configuration mode.

## Applying RA Guard Policy

Applying the RA Guard policy on the device will block all the untrusted RA's.

To apply RA guard policy, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>interface tengigabitethernet 1/0/1</b> <b>Example:</b> Device(config)# <b>interface</b> <b>tengigabitethernet 1/0/1</b>	Specifies an interface type and number, and places the device in interface configuration mode.
<b>Step 4</b>	<b>ipv6 nd rguard attach-policy</b> <b>rguard-router</b> <b>Example:</b> Device(config-if)# <b>ipv6 nd rguard</b> <b>attach-policy rguard-router</b>	Applies the IPv6 RA Guard feature to a specified interface.
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config-if)# <b>exit</b>	Exits interface configuration mode.

## Configuring RA Throttle Policy (CLI)

Configure RA Throttle policy to allow the enforce the limits

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>ipv6 nd ra-throttler policy</b> <b>ra-throttler1</b> <b>Example:</b> Device(config)# <b>ipv6 nd ra-throttler</b> <b>policy ra-throttler1</b>	Define the router advertisement (RA) throttler policy name and enter IPv6 RA throttle policy configuration mode.
<b>Step 3</b>	<b>throttleperiod500</b> <b>Example:</b> Device(config-nd-ra-throttle)# <b>throttleperiod 500</b>	Configures the throttle period in an IPv6 RA throttler policy.
<b>Step 4</b>	<b>max-through10</b> <b>Example:</b> Device(config-nd-ra-throttle)# <b>max-through 500</b>	Limits multicast RAs per VLAN per throttle period.

	Command or Action	Purpose
<b>Step 5</b>	<b>allow-atleast 5 at-most 10</b> <b>Example:</b> Device(config-nd-ra-throttle)# allow-atleast 5 at-most 10	Limits the number of multicast RAs per device per throttle period in an RA throttler policy.

## Applying RA Throttle Policy on VLAN (CLI)

Applying the RA Throttle policy on a VLAN. By enabling RA throttling, routers that send many RA packets can be trimmed to a minimum frequency that will still maintain an IPv6 client connectivity.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>vlan configuration 1</b> <b>Example:</b> Device(config)# <b>vlan configuration 1</b>	Configures a VLAN or a collection of VLANs and enters VLAN configuration mode.
<b>Step 3</b>	<b>ipv6 nd ra throttler attach-policy ra-throttler1</b> <b>Example:</b> Device(config-vlan)# <b>ipv6 nd ra throttler attach-policy ra-throttler1</b>	Attaches an IPv6 RA throttler policy to a VLAN or a collection of VLANs.

## How to Configure IPv6 Neighbor Probing

For IPv6 Neighbor Probing to work, the binding table needs to be populated. To provide fine tuning for the life cycle of an entry in the binding table, perform this task.

A single IPv6 client can have multiple IPv6 addresses at any given time. When you execute the command **show ipv6 neighbor binding mac mac\_address**, these addresses display the state as *REACHABLE* in the IPv6 neighbor binding table for that client's MAC address. If there is no control activity on these addresses for 300 seconds, they move to *STALE* state and become unusable by the client thereafter.

**device-tracking tracking** command is used to send periodic probes (default time period is 300 seconds) to all IPv6 clients to ensure that the client's IPv6 address(s) do not age out and move to *STALE* state. These probes are sent from the switch with a source IP address of all zeros which is a Duplicate address detection (DAD) probe. There are a few clients which do not respond to DAD probes and hence age out after 300 seconds.



**Note** You should enable IPv6 Neighbor Probing only if there is a network issue with respect to hosts having difficulty to obtain or keep their IP addresses. Specifically, if a DAD probe is issued to a host during the timing window when the host is negotiating its IP lease renewal, the DAD challenge can result in the host giving up its IP address. Enabling IPv6 Neighbor Probing gratuitously can cause unexpected host behavior.



**Note** For Cisco IOS 15.2(5)E release and earlier, you need to remove the IPv6 Snooping policy at the interface level and attach the policy at the VLAN level. Perform step 8 and step 9 to attach the IPv6 Snooping policy at the VLAN level.

If IPv6 Neighbor Probing is enabled on a VLAN, additional configuration must be done to prevent learning and hosts over trunk ports. To disable learning over trunk ports, you must configure a policy with a **trusted-port** and **device-role switch**. This configuration requires that other access switches connected to trunk ports have policies to provide first hop security for their own connected hosts. Each switch should provide security for their hosts. Perform step 10 to step 12 to configure a policy with these attributes.

Follow the steps below to configure IPv6 Neighbor Probing.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>device-tracking tracking</b> <b>Example:</b>  Device(config)# device-tracking tracking	Enables IPv6 neighbor probing.  To disable IPv6 neighbor probing, use the <b>no</b> form of this command.
<b>Step 4</b>	<b>interface vlan <i>vlan-id</i></b> <b>Example:</b>  Device(config)# interface vlan 1810	Enters interface configuration mode, and enters the VLAN to which the IP information is assigned. The range is 1 to 4094.
<b>Step 5</b>	<b>ipv6 enable</b> <b>Example:</b>  Device(config-if)# ipv6 enable	Enables IPv6 processing on an interface that has not been configured with an explicit IPv6 address.

	Command or Action	Purpose
		<p><b>Note</b> When you create an SVI on VLAN with <b>ipv6 enable</b> configured on it, it results in the link local address of the SVI being used as the probe source address. Hence, probing is performed as an NS message rather than a DAD message. This configuration results in a higher probe response rate. Certain hosts may ignore DAD requests. However, all hosts respond to an NS message.</p>
<b>Step 6</b>	<p><b>no shutdown</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# no shutdown</pre>	<p>Enables the interface.</p> <p>If dot1x is enabled for IPv4, the policies on the interfaces where dot1x is enabled will automatically be configured and tracking will be enabled specifically for IPv6 Neighbor Probing. In this case, changing the tracking behavior at a global configuration level will have no impact on the tracking for these automatically configured policies. Tracking will always be enabled on all the interfaces.</p>
<b>Step 7</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# exit</pre>	<p>Exits interface configuration mode.</p>
<b>Step 8</b>	<p><b>vlan configuration</b> <i>vlan_list</i></p> <p><b>Example:</b></p> <pre>Device(config)# vlan configuration 1815</pre>	<p>Specifies the VLANs to which the IPv6 Snooping policy will be attached ; enters the VLAN interface configuration mode.</p>
<b>Step 9</b>	<p><b>ipv6 snooping</b> [<b>attach-policy</b> <i>policy_name</i>]</p> <p><b>Example:</b></p> <pre>Device(config-vlan-config)# ipv6 snooping attach-policy example_policy</pre>	<p>Attaches the IPv6 Snooping policy to the specified VLANs across all switch and stack interfaces. The default policy is attached if the attach-policy option is not used. The default policy is, security-level guard, device-role node, protocol ndp and dhcp.</p>

	Command or Action	Purpose
		<p><b>Note</b> If the same user-defined policy is configured on all interfaces, then this policy can be configured on the VLAN, and it can be removed from the interfaces. If different policies are configured on the interfaces, the policies configured on the interfaces should not be removed and the above default policy should be applied at the VLAN level.</p>
<b>Step 10</b>	<p><b>ipv6 snooping policy</b> <i>policy_name</i></p> <p><b>Example:</b></p> <pre>Device(config-vlan-config)# ipv6 snooping policy example_policy</pre>	Configures an IPv6 snooping policy and enters IPv6 snooping configuration mode.
<b>Step 11</b>	<p><b>trusted-port</b></p> <p><b>Example:</b></p> <pre>Device(config-ipv6-snooping)# trusted-port</pre>	Configures a port to become a trusted port.
<b>Step 12</b>	<p><b>device-role switch</b></p> <p><b>Example:</b></p> <pre>Device(config-ipv6-snooping)# device-role switch</pre>	Sets the role of the device that is attached to the switch.
<b>Step 13</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-ipv6-snooping)# end</pre>	Exits configuration mode.

## Configuring IPv6 Snooping

IPv6 snooping must always be enabled on the switch and the controller.

To configuring IPv6 snooping, perform this procedure:

### Before you begin

Enable IPv6 on the client machine.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>vlan configuration 1</b> <b>Example:</b> Device(config)# <b>vlan configuration 1</b>	Enters VLAN configuration mode.
<b>Step 4</b>	<b>ipv6 snooping</b> <b>Example:</b> Device(config-vlan)# <b>ipv6 snooping</b>	Enables IPv6 snooping on the Vlan.
<b>Step 5</b>	<b>ipv6 nd suppress</b> <b>Example:</b> Device(config-vlan-config)# <b>ipv6 nd suppress</b>	Enables the IPv6 ND suppress on the Vlan.
<b>Step 6</b>	<b>exit</b> <b>Example:</b> Device(config-vlan-config)# <b>exit</b>	Saves the configuration and comes out of the Vlan configuration mode.

## Configuring IPv6 ND Suppress Policy

The IPv6 neighbor discovery (ND) multicast suppress feature stops as many ND multicast neighbor solicit (NS) messages as possible by dropping them (and responding to solicitations on behalf of the targets) or converting them into unicast traffic. This feature runs on a layer 2 switch or a wireless controller and is used to reduce the amount of control traffic necessary for proper link operations.

When an address is inserted into the binding table, an address resolution request sent to a multicast address is intercepted, and the device either responds on behalf of the address owner or, at layer 2, converts the request into a unicast message and forwards it to its destination.

To configure IPv6 ND suppress policy, perform this procedure:

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 nd suppress policy</b> <b>Example:</b> Device(config)# <b>ipv6 nd suppress policy</b>	Defines the ND suppress policy name and enters ND suppress policy configuration mode.

## Configuring IPv6 Snooping on VLAN/PortChannel

Neighbor Discover (ND) suppress can be enabled or disabled on either the VLAN or a switchport.

To configure IPv6 snooping on VLAN/PortChannel, perform this procedure:

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>vlan config901</b> <b>Example:</b> Device(config)# <b>vlan config901</b>	Creates a VLAN and enter the VLAN configuration mode
<b>Step 4</b>	<b>ipv6 nd suppress</b> <b>Example:</b> Device(config-vlan)# <b>ipv6 nd suppress</b>	Applies the IPv6 nd suppress on VLAN.



	Command or Action	Purpose
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-vlan)# <b>end</b>	Exits vlan configuration mode and enters the global configuration mode.
<b>Step 6</b>	<b>interface gi1/0/1</b> <b>Example:</b> Device(config)# <b>interface gi1/0/1</b>	Creates a gigabitethernet port interface.
<b>Step 7</b>	<b>ipv6 nd suppress</b> <b>Example:</b> Device(config-vlan)# <b>ipv6 nd suppress</b>	Applies the IPv6 nd suppress on the interface.
<b>Step 8</b>	<b>end</b> <b>Example:</b> Device(config-vlan)# <b>end</b>	Exits vlan configuration mode and enters the global configuration mode.

## Configuring IPv6 on Interface

Follow the procedure given below to configure IPv6 on an interface:

### Before you begin

Enable IPv6 on the client and IPv6 support on the wired infrastructure.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface vlan 1</b> <b>Example:</b> Device(config)# <b>interface vlan 1</b>	Creates a interface and enters interface configuration mode.
<b>Step 4</b>	<b>ip address fe80::1 link-local</b> <b>Example:</b>	Configures IPv6 address on the interface using the link-local option.

	Command or Action	Purpose
	<pre>Device(config-if)# ip address 198.51.100.1 255.255.255.0 Device(config-if)# ipv6 address fe80::1 link-local Device(config-if)# ipv6 address 2001:DB8:0:1:FFFF:1234::5/64 Device(config-if)# ipv6 address 2001:DB8:0:0:E000::F/64</pre>	
<b>Step 5</b>	<p><b>ipv6 enable</b></p> <p><b>Example:</b></p> <pre>Device(config)# ipv6 enable</pre>	(Optional) Enables IPv6 on the interface.
<b>Step 6</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Exits from the interface mode.

## Configuring DHCP Pool

Follow the procedure given below to configure DHCP Pool on an interface:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<p><b>ipv6 dhcp pool Vlan21</b></p> <p><b>Example:</b></p> <pre>Device(config)# ipv6 dhcp pool vlan1</pre>	Enters the configuration mode and configures the IPv6 DHCP pool on the Vlan.
<b>Step 4</b>	<p><b>address prefix</b></p> <p><b>2001:DB8:0:1:FFFF:1234::/64</b></p> <p><b>lifetime 300 10</b></p> <p><b>Example:</b></p> <pre>Device(config-dhcpv6)# address prefix 2001:DB8:0:1:FFFF:1234::/64 lifetime 300 10</pre>	Enters the configuration-dhcp mode and configures the address pool and its lifetime on a Vlan.

	Command or Action	Purpose
<b>Step 5</b>	<b>dns-server 2001:100:0:1::1</b> <b>Example:</b> Device(config-dhcpv6)# <b>dns-server</b> 2001:20:21::1	Configures the DNS servers for the DHCP pool.
<b>Step 6</b>	<b>domain-name example.com</b> <b>Example:</b> Device(config-dhcpv6)# <b>domain-name</b> example.com	Configures the domain name to complete unqualified host names.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring Stateless Auto Address Configuration Without DHCP (CLI)

Follow the procedure given below to configure stateless auto address configuration without DHCP:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface vlan 1</b> <b>Example:</b> Device(config)# <b>interface vlan 1</b>	Creates a interface and enters interface configuration mode.
<b>Step 4</b>	<b>ip address fe80::1 link-local</b> <b>Example:</b> Device(config-if)# <b>ip address</b> 198.51.100.1 255.255.255.0 Device(config-if)# <b>ipv6 address</b> fe80::1 link-local Device(config-if)# <b>ipv6 address</b>	Configures IPv6 address on the interface using the link-local option.

	Command or Action	Purpose
	<pre>2001:DB8:0:1:FFFF:1234::5/64 Device(config-if)# ipv6 address 2001:DB8:0:0:E000::F/64</pre>	
<b>Step 5</b>	<b>ipv6 enable</b> <b>Example:</b> <pre>Device(config)# ipv6 enable</pre>	(Optional) Enables IPv6 on the interface.
<b>Step 6</b>	<b>no ipv6 nd managed-config-flag</b> <b>Example:</b> <pre>Device(config)# interface vlan 1 Device(config-if)# no ipv6 nd managed-config-flag</pre>	Ensures the attached hosts do not use stateful autoconfiguration to obtain addresses.
<b>Step 7</b>	<b>no ipv6 nd other-config-flag</b> <b>Example:</b> <pre>Device(config-if)# no ipv6 nd other-config-flag</pre>	Ensures the attached hosts do not use stateful autoconfiguration to obtain non-address options from DHCP (domain etc).
<b>Step 8</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring Stateless Auto Address Configuration With DHCP

Follow the procedure given below to configure stateless auto address configuration with DHCP:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>interface vlan 1</b> <b>Example:</b> <pre>Device(config)# interface vlan 1</pre>	Creates a interface and enters interface configuration mode.

	Command or Action	Purpose
<b>Step 4</b>	<b>ip address fe80::1 link-local</b> <b>Example:</b> Device(config-if)# <b>ip address</b> <b>198.51.100.1 255.255.255.0</b> Device(config-if)# <b>ipv6 address</b> <b>fe80::1 link-local</b> Device(config-if)# <b>ipv6 address</b> <b>2001:DB8:0:1:FFFF:1234::5/64</b> Device(config-if)# <b>ipv6 address</b> <b>2001:DB8:0:0:E000::F/64</b>	Configures IPv6 address on the interface using the link-local option.
<b>Step 5</b>	<b>ipv6 enable</b> <b>Example:</b> Device(config)# <b>ipv6 enable</b>	(Optional) Enables IPv6 on the interface.
<b>Step 6</b>	<b>no ipv6 nd managed-config-flag</b> <b>Example:</b> Device(config)# <b>interface vlan 1</b> Device(config-if)# <b>no ipv6 nd</b> <b>managed-config-flag</b>	Ensures the attached hosts do not use stateful autoconfiguration to obtain addresses.
<b>Step 7</b>	<b>ipv6 nd other-config-flag</b> <b>Example:</b> Device(config-if)# <b>no ipv6 nd</b> <b>other-config-flag</b>	Ensures the attached hosts do not use stateful autoconfiguration to obtain non-address options from DHCP (domain etc).
<b>Step 8</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Exits from the interface mode.

## Configuring Stateful DHCP Locally

This interface configuration is for a Cisco IOS IPv6 router implementing stateful DHCPv6 on a local Device

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <b>configure terminal</b>	
<b>Step 3</b>	<b>ipv6 unicast-routing</b> <b>Example:</b> Device (config)# <b>ipv6 unicast-routing</b>	Configures IPv6 for unicasting.
<b>Step 4</b>	<b>ipv6 dhcp pool IPv6_DHCPOOL</b> <b>Example:</b> Device (config)# <b>ipv6 dhcp pool</b> <b>IPv6_DHCPOOL</b>	Enters the configuration mode and configures the IPv6 DHCP pool on the VLAN.
<b>Step 5</b>	<b>address prefix</b> <b>2001:DB8:0:1:FFFF:1234::/64</b> <b>Example:</b> Device (config-dhcpv6)# <b>address prefix</b> <b>2001:DB8:0:1:FFFF:1234::/64</b>	Specifies the address range to provide in the pool.
<b>Step 6</b>	<b>dns-server 2001:100:0:1::1</b> <b>Example:</b> Device (config-dhcpv6)# <b>dns-server</b> <b>2001:100:0:1::1</b>	Provides the DNS server option to DHCP clients.
<b>Step 7</b>	<b>domain-name example.com</b> <b>Example:</b> Device (config-dhcpv6)# <b>domain-name</b> <b>example.com</b>	Provides the domain name option to DHCP clients.
<b>Step 8</b>	<b>exit</b> <b>Example:</b> Device (config-dhcpv6)# <b>exit</b>	Returns to the previous mode.
<b>Step 9</b>	<b>interface vlan1</b> <b>Example:</b> Device (config)# <b>interface vlan 1</b>	Enters the interface mode to configure the stateful DHCP.
<b>Step 10</b>	<b>description IPv6-DHCP-Stateful</b> <b>Example:</b> Device (config-if)# <b>description</b> <b>IPv6-DHCP-Stateful</b>	Enter description for the stateful IPv6 DHCP.
<b>Step 11</b>	<b>ipv6 address 2001:DB8:0:20::1/64</b> <b>Example:</b> Device (config-if)# <b>ipv6 address</b> <b>2001:DB8:0:20::1/64</b>	Enters the IPv6 address for the stateful IPv6 DHCP.

	Command or Action	Purpose
<b>Step 12</b>	<b>ip address 192.168.20.1 255.255.255.0</b>  <b>Example:</b> Device (config-if)# <b>ip address 192.168.20.1 255.255.255.0</b>	Enters the IPv6 address for the stateful IPv6 DHCP.
<b>Step 13</b>	<b>ipv6 nd prefix 2001:db8::/64 no-advertise</b>  <b>Example:</b> Device (config-if)# <b>ipv6 nd prefix 2001:db8::/64 no-advertise</b>	Configures the IPv6 routing prefix advertisement that must not be advertised.
<b>Step 14</b>	<b>ipv6 nd managed-config-flag</b>  <b>Example:</b> Device (config-if)# <b>ipv6 nd managed-config-flag</b>	Configures IPv6 interfaces neighbor discovery to allow the hosts to uses DHCP for address configuration.
<b>Step 15</b>	<b>ipv6 nd other-config-flag</b>  <b>Example:</b> Device (config-if)# <b>ipv6 nd other-config-flag</b>	Configures IPv6 interfaces neighbor discovery to allow the hosts to uses DHCP for non-address configuration.
<b>Step 16</b>	<b>ipv6 dhcp server IPv6_DHCPPPOOL</b>  <b>Example:</b> Device (config-if)# <b>ipv6 dhcp server IPv6_DHCPPPOOL</b>	Configures the DHCP server on the interface.

## Configuring Stateful DHCP Externally

This interface configuration is for a Cisco IOS IPv6 router implementing stateful DHCPv6 on an external DHCP server.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode.  Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>ipv6 unicast-routing</b> <b>Example:</b> Device(config)# <b>ipv6 unicast-routing</b>	Configures the IPv6 for unicasting.
<b>Step 4</b>	<b>dns-server 2001:100:0:1::1</b> <b>Example:</b> Device(config-dhcpv6)# <b>dns-server 2001:100:0:1::1</b>	Provides the DNS server option to DHCP clients.
<b>Step 5</b>	<b>domain-name example.com</b> <b>Example:</b> Device(config-dhcpv6)# <b>domain-name example.com</b>	Provides the domain name option to DHCP clients.
<b>Step 6</b>	<b>exit</b> <b>Example:</b> Device(config-dhcpv6)# <b>exit</b>	Returns to the previous mode.
<b>Step 7</b>	<b>interface vlan1</b> <b>Example:</b> Device(config)# <b>interface vlan 1</b>	Enters the interface mode to configure the stateful DHCP.
<b>Step 8</b>	<b>description IPv6-DHCP-Stateful</b> <b>Example:</b> Device(config-if)# <b>description IPv6-DHCP-Stateful</b>	Enter description for the stateful IPv6 DHCP.
<b>Step 9</b>	<b>ipv6 address 2001:DB8:0:20::1/64</b> <b>Example:</b> Device(config-if)# <b>ipv6 address 2001:DB8:0:20::1/64</b>	Enters the IPv6 address for the stateful IPv6 DHCP.
<b>Step 10</b>	<b>ip address 192.168.20.1 255.255.255.0</b> <b>Example:</b> Device(config-if)# <b>ip address 192.168.20.1 255.255.255.0</b>	Enters the IPv6 address for the stateful IPv6 DHCP.
<b>Step 11</b>	<b>ipv6 nd prefix 2001:db8::/64 no-advertise</b> <b>Example:</b> Device(config-if)# <b>ipv6 nd prefix 2001:db8::/64 no-advertise</b>	Configures the IPv6 routing prefix advertisement that must not be advertised.



	Command or Action	Purpose
<b>Step 12</b>	<b>ipv6 nd managed-config-flag</b> <b>Example:</b> Device(config-if)# <b>ipv6 nd managed-config-flag</b>	Configures IPv6 interfaces neighbor discovery to allow the hosts to uses DHCP for address configuration.
<b>Step 13</b>	<b>ipv6 nd other-config-flag</b> <b>Example:</b> Device(config-if)# <b>ipv6 nd other-config-flag</b>	Configures IPv6 interfaces neighbor discovery to allow the hosts to uses DHCP for non-address configuration.
<b>Step 14</b>	<b>ipv6 dhcp relaydestination 2001:DB8:0:20::2</b> <b>Example:</b> Device(config-if)# <b>ipv6 dhcp relay destination 2001:DB8:0:20::2</b>	Configures the DHCP server on the interface.

## Verifying IPv6 Address Learning Configuration

This example displays the output of the **show ipv6 dhcp pool** command. This command displays the IPv6 service configuration on the device. The vlan 21 configured pool detail displays 6 clients that are currently using addresses from the pool.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>show ipv6 dhcp pool</b> <b>Example:</b> Device# show ipv6 dhcp pool DHCPv6 pool: vlan21 Address allocation prefix: 2001:DB8:0:1:FFFF:1234::/64 valid 86400 preferred 86400 (6 in use, 0 conflicts) DNS server: 2001:100:0:1::1 Domain name: example.com Active clients: 6	Displays the IPv6 service configuration on the device.

## Additional References

### Related Documents

Related Topic	Document Title
IPv6 command reference	<i>IPv6 Command Reference (Catalyst 3850 Switches)</i>
IP command reference	<i>IP Command Reference (Catalyst 3850 Switches)</i>

**Error Message Decoder**

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for IPv6 Client Address Learning

This table lists the features in this module and provides links to specific configuration information:

Feature	Release	Modification
IPv6 Client Address Learning Functionality	Cisco IOS XE 3.2SE	This feature was introduced.



## CHAPTER 18

# Configuring IPv6 WLAN Security

- [Prerequisites for IPv6 WLAN Security, on page 301](#)
- [Restrictions for IPv6 WLAN Security, on page 301](#)
- [Information About IPv6 WLAN Security, on page 301](#)
- [How to Configure IPv6 WLAN Security, on page 304](#)
- [Additional References , on page 318](#)
- [Feature Information for IPv6 WLAN Security, on page 318](#)

## Prerequisites for IPv6 WLAN Security

A client VLAN must be mapped to the WLAN configured on the device

## Restrictions for IPv6 WLAN Security

### RADIUS Server Support

- If multiple RADIUS servers are configured for redundancy, the user database must be identical in all the servers for the backup to work properly.

### Radius ACS Support

- You must configure RADIUS on both your Cisco Secure Access Control Server (ACS) and your device
- RADIUS is supported on Cisco Secure ACS version 3.2 and later releases.

## Information About IPv6 WLAN Security

### Information About RADIUS

Remote Authentication Dial-In User Service (RADIUS) is a client/server protocol that provides centralized security for users attempting to gain management access to a network. It serves as a back-end database similar to Local EAP and provides authentication and accounting services.

- **Authentication**—The process of verifying users when they attempt to log into the device

Users must enter a valid username and password for the device to authenticate users to the RADIUS server. If multiple databases are configured, then specify the sequence in which the backend database must be tried.

- **Accounting**— The process of recording user actions and changes.

Whenever a user successfully executes an action, the RADIUS accounting server logs the changed attributes, the user ID of the person who made the change, the remote host where the user is logged in, the date and time when the command was executed, the authorization level of the user, and a description of the action performed and the values provided. If the RADIUS accounting server is unreachable, the users can continue their sessions uninterrupted.

**User Datagram Protocol**— RADIUS uses User Datagram Protocol (UDP) for its transport. It maintains a database and listens on UDP port 1812 for incoming authentication requests and UDP port 1813 for incoming accounting requests. The device, which requires access control, acts as the client and requests AAA services from the server. The traffic between the device and the server is encrypted by an algorithm defined in the protocol and a shared secret key configured on both devices.

Configures multiple RADIUS accounting and authentication servers. For example, you can have one central RADIUS authentication server but several RADIUS accounting servers in different regions. If you configure multiple servers of the same type and the first one fails or becomes unreachable, the controller automatically tries the second one, then the third one if necessary, and so on.

When RADIUS method is configured for the WLAN, the device will use the RADIUS method configured for the WLAN. When the WLAN is configured to use local EAP, the RADIUS method configured on the WLAN points to Local. The WLAN must also be configured with the name of the local EAP profile to use.

If no RADIUS method is configured in the WLAN, the device will use the default RADIUS method defined in global mode.

### Information About Local EAP

Local EAP is an authentication method that allows users and wireless clients to be authenticated locally. It is designed for use in remote offices that maintain connectivity to wireless clients when the back-end system is disrupted or the external authentication server goes down. When you enable local EAP, the device serves as the authentication server and the local user database, which removes dependence on an external authentication server. Local EAP retrieves user credentials from the local user database or the LDAP back-end database to authenticate users. Local EAP supports LEAP, EAP-FAST, EAP-TLS, PEAPv0/MSCHAPv2, and PEAPv1/GTC authentication between the controller and wireless clients.

Without an EAP profile name being provided, or if a name was provided for an EAP profile that does not exist, then EAP by default allows no EAP method for local authentication.



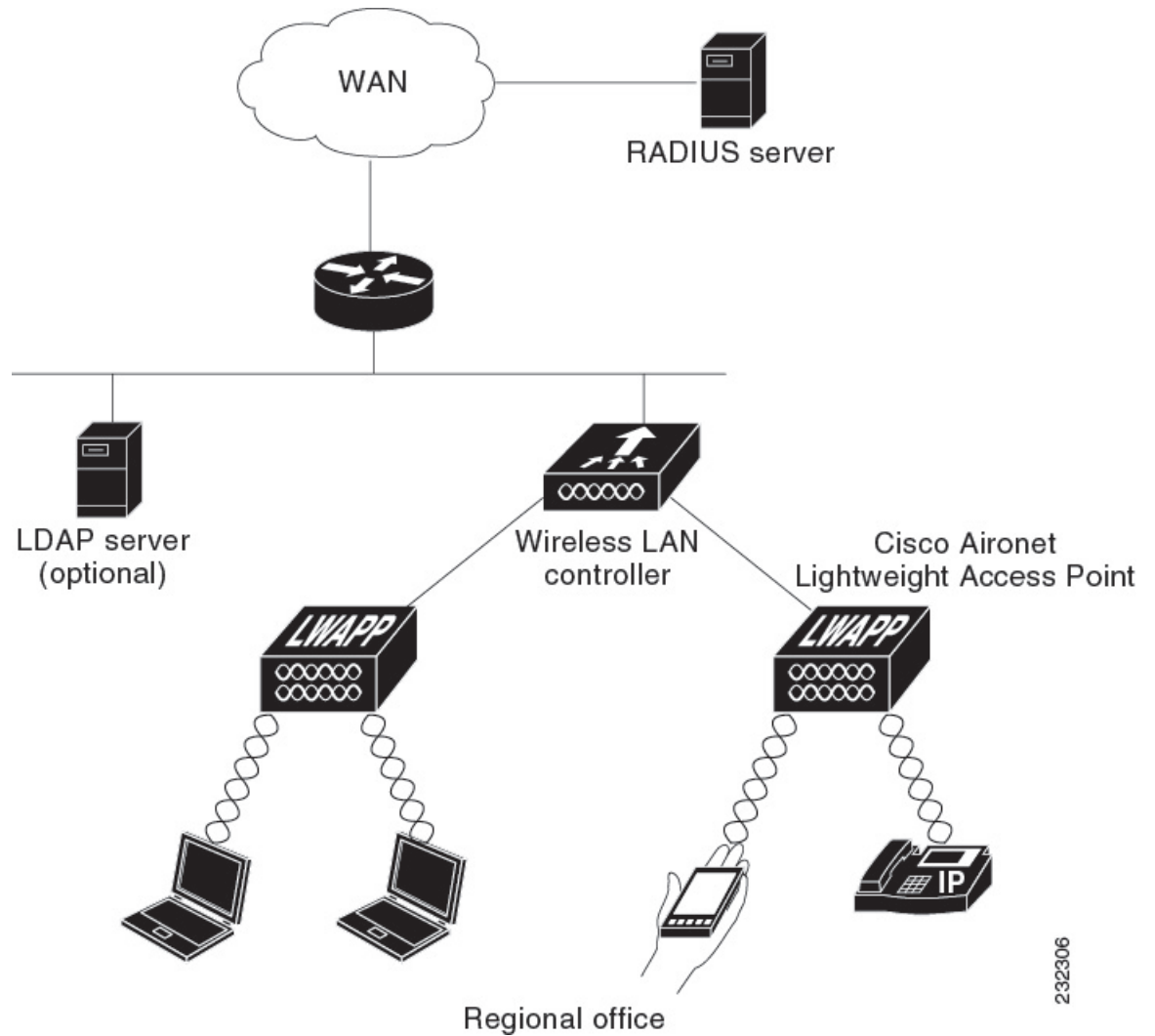
#### Note

The LDAP back-end database supports these local EAP methods: EAP-TLS, EAP-FAST/GTC, and PEAPv1/GTC. LEAP, EAP-FAST/MSCHAPv2, and PEAPv0. MSCHAPv2 is supported only if the LDAP server is set up to return a clear-text password.



**Note** Device support Local EAP authentication against external LDAP databases such as Microsoft Active Directory and Novell's eDirectory. For more information about configuring the controller for Local EAP authentication against Novell's eDirectory, see the Configure Unified Wireless Network for Authentication Against Novell's eDirectory Database whitepaper.

**Figure 13: Local EAP Example**



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# How to Configure IPv6 WLAN Security

## Configuring Local Authentication

### Creating a Local User

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>username aaa_test</b> <b>Example:</b> Device(config)# <code>username aaa_test</code>	Creates a username.
<b>Step 3</b>	<b>password 0 aaa_test</b> <b>Example:</b> Device(config)# <code>usernameaaa_test</code> <code>password 0 aaa_test</code>	Assigns a password for the username.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit the global configuration mode.

```
Device# configure terminal
Device(config)# username aaa_test password 0 aaa_test
Device(config)# end
```

### Creating an Client VLAN and Interface

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>vlan</b> <b>Example:</b> Device(config)# <code>vlan 137</code>	Creates a VLAN.

	Command or Action	Purpose
<b>Step 3</b>	<b>exit</b> <b>Example:</b> Device (config-vlan)# exit	Exits VLAN configuration mode.
<b>Step 4</b>	<b>interface vlan v1an_ID</b> <b>Example:</b> Device (config)# interface vlan 137	Associates the VLAN to an interface.
<b>Step 5</b>	<b>ip address</b> <b>Example:</b> Device(config-if)# ip address 10.7.137.10 255.255.255.0	Assigns an IP address to the VLAN interface.
<b>Step 6</b>	<b>ipv6 address</b> <b>Example:</b> Device(config-if)#ipv6 address 2001:db8::20:1/64	Assigns an IPv6 address to the VLAN interface.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit the global configuration mode.

**Example**

```
Device# configure terminal
Device(config)# vlan 137
Device(config-vlan)#exit
Device(config)#interface vlan 137
Device(config-if)#ip address 10.7.137.10 255.255.255.0
Device(config-if)#ipv6 address 2001:db8::20:1/64
Device(config-if)#end
```

**Configuring an EAP Profile****Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>eap profile name</b> <b>Example:</b> Device (config) # eap profile wcm_eap_prof	Creates an EAP profile.
<b>Step 2</b>	<b>method leap</b> <b>Example:</b> Device (config-eap-profile) # method leap	Configures EAP-LEAP method on the profile.

	Command or Action	Purpose
<b>Step 3</b>	<b>method tls</b> <b>Example:</b> Device(config-eap-profile)# method tls	Configures EAP-TLS method on the profile.
<b>Step 4</b>	<b>method peap</b> <b>Example:</b> Device(config-eap-profile)# method peap	Configures PEAP method on the profile.
<b>Step 5</b>	<b>method fast</b> <b>Example:</b> Device(config-eap-profile)# method fast	Configures EAP-FAST method on the profile.
<b>Step 6</b>	<b>method mschapv2</b> <b>Example:</b> Device(config-eap-profile)# method mschapv2	Configures EAP-MSCHAPV2 method on the profile.
<b>Step 7</b>	<b>method md5</b> <b>Example:</b> Device(config-eap-profile)# method md5	Configures EAP-MD5 method on the profile.
<b>Step 8</b>	<b>method gtc</b> <b>Example:</b> Device(config-eap-profile)# method gtc	Configures EAP-GTC method on the profile.
<b>Step 9</b>	<b>method fast profile my-fast</b> <b>Example:</b> Device(config-eap-profile)# eap method fast profile my-fast Device(config-eap-profile)#description my_local eap profile	Creates a EAP profile named my-fast.
<b>Step 10</b>	<b>description my_local eap profile</b> <b>Example:</b> Device(config-eap-profile)#description my_local eap profile	Provides a description for the local profile.
<b>Step 11</b>	<b>exit</b> <b>Example:</b> Device(config-eap-profile)# exit	Exits the eap-profile configuration mode.
<b>Step 12</b>	<b>eap method fast profile myFast</b> <b>Example:</b> Device(config)# eap method fast profile myFast	Configures the EAP method profile.



	Command or Action	Purpose
<b>Step 13</b>	<b>authority-id [identity information]</b> <b>Example:</b> <pre>Device(config-eap-method-profile)# authority-id identity my_identity Device(config-eap-method-profile)#authority-id information my_information</pre>	Configure the authority ID and information for the EAP method profile.
<b>Step 14</b>	<b>local-key 0 key-name</b> <b>Example:</b> <pre>Device(config-eap-method-profile)# local-key 0 test</pre>	Configures the local server key.
<b>Step 15</b>	<b>pac-password 0 password</b> <b>Example:</b> <pre>Device(config-eap-method-profile)# pac-password 0 test</pre>	Configures the PAC password for manual PAC provisioning.
<b>Step 16</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit the global configuration mode.

### Example

```
Device(config)#eap profile wcm_eap_prof
Device(config-eap-profile)#method leap
Device(config-eap-profile)#method tls
Device(config-eap-profile)#method peap

Device(config-eap-profile)#method mschapv2
Device(config-eap-profile)#method md5
Device(config-eap-profile)#method gtc
Device(config-eap-profile)#eap method fast profile my-fast

Device (config-eap-profile)#description my_local eap profile
Device(config-eap-profile)# exit
Device (config)# eap method fast profile myFast
Device(config-eap-method-profile)#authority-id identity my_identity
Device(config-eap-method-profile)#authority-id information my_information
Device(config-eap-method-profile)#local-key 0 test
Device(config-eap-method-profile)#pac-password 0 test
Device(config-eap-method-profile)# end
```

## Creating a Local Authentication Model

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>aaa new-model</b> <b>Example:</b>	Creates a AAA authentication model.

	Command or Action	Purpose
	Device(config)# aaa new-model	
<b>Step 2</b>	<b>authentication dot1x default local</b> <b>Example:</b> Device(config)# aaa authentication dot1x default local	Implies that the dot1x must use the default local RADIUS when no other method is found.
<b>Step 3</b>	<b>dot1x method_list local</b> <b>Example:</b> Device(config)# aaa authentication dot1x wcm_local local	Assigns the local authentication for wcm_local method list.
<b>Step 4</b>	<b>aaa authentication dot1x dot1x_name local</b> <b>Example:</b> Device(config)# aaa authentication dot1x aaa_auth local	Configures the local authentication for the dot1x method.
<b>Step 5</b>	<b>aaa authorization credential-download name local</b> <b>Example:</b> Device(config)# aaa authorization credential-download wcm_author local	Configures local database to download EAP credentials from Local/RADIUS/LDAP.
<b>Step 6</b>	<b>aaa local authentication auth-name authorization authorization-name</b> <b>Example:</b> Device(config)# aaa local authentication wcm_local authorization wcm_author	Selects local authentication and authorization.
<b>Step 7</b>	<b>session ID</b> <b>Example:</b> Device(config)# aaa session-id common	Configures a session ID for AAA.
<b>Step 8</b>	<b>dot1x system-auth-control</b> <b>Example:</b> Device(config)# dot1x system-auth-control	Enables dot.1x system authentication control.

### Example

```
Device(config)# aaa new-model
Device(config)# aaa authentication dot1x default local
Device(config)# aaa authentication dot1x wcm-local local
Device(config)# aaa authentication dot1x aaa_auth local
Device(config)# aaa authorization credential-download wcm_author local
Device(config)# aaa local authentication wcm_local authorization wcm_author
```

```
Device(config)# aaa session-id common
Device(config)# dot1x system-auth-control
```

## Creating a Client WLAN



**Note** This example uses 802.1x with dynamic WEP. You can use any other security mechanism supported by the wireless client and configurable on the device

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan wlan name &lt;identifier&gt; SSID</b> <b>Example:</b> Device(config)# wlan wlanProfileName 1 ngwcSSID	Creates a WLAN.
<b>Step 3</b>	<b>broadcast-ssid</b> <b>Example:</b> Device(config-wlan)# broadcast-ssid	Configures to broadcast the SSID on a WLAN.
<b>Step 4</b>	<b>no security wpa</b> <b>Example:</b> Device(config-wlan)# no security wpa	Disables the wpa for WLAN to enable 802.1x.
<b>Step 5</b>	<b>security dot1x</b> <b>Example:</b> Device(config-wlan)# security dot1x	Configures the 802.1x encryption security for the WLAN.
<b>Step 6</b>	<b>security dot1x authentication-list wcm-local</b> <b>Example:</b> Device(config-wlan)# security dot1x authentication-list wcm-local	Configures the server group mapping to the WLAN for dot1x authentication.
<b>Step 7</b>	<b>local-auth wcm_eap_prof</b> <b>Example:</b> Device (config-wlan)# local-auth wcm_eap_profile	Configures the eap profile on the WLAN for local authentication.
<b>Step 8</b>	<b>client vlan 137</b> <b>Example:</b> Device(config-wlan)# client vlan 137	Associates the VLAN to a WLAN.

	Command or Action	Purpose
<b>Step 9</b>	<b>no shutdown</b> <b>Example:</b> Device(config-wlan)# no shutdown	Enables the WLAN.
<b>Step 10</b>	<b>end</b> <b>Example:</b> Device(config)# end	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit the global configuration mode.

**Example**

```

Device# config terminal
Device(config)#wlan wlanProfileName 1 ngwcSSID
Device(config-wlan)#broadcast-ssid
Device(config-wlan)#no security wpa
Device(config-wlan)#security dot1x
Device(config-wlan)#security dot1x authentication-list wcm-local
Device (config-wlan)# local-auth wcm_eap_prof
Device(config-wlan)#client vlan 137
Device(config-wlan)#no shutdown
Device(config-wlan)#end
Device#

```

**Configuring Local Authentication with WPA2+AES****Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>aaa new model</b> <b>Example:</b> Device(config)# aaa <b>new-model</b>	Creates a AAA authentication model.
<b>Step 3</b>	<b>dot1x system-auth-control</b> <b>Example:</b> Device(config)# dot1x system-auth-control	Enables dot1x system authentication control.
<b>Step 4</b>	<b>aaa authentication dot1x default local</b> <b>Example:</b> Device(config)# aaa authentication dot1x default local	Configures the local authentication for the default dot1x method.

	Command or Action	Purpose
<b>Step 5</b>	<b>aaa local authorization credential-download default local</b>  <b>Example:</b> Device(config)# aaa authorization credential-download default local	Configures default database to download EAP credentials from local server.
<b>Step 6</b>	<b>aaa local authentication default authorization default</b>  <b>Example:</b> Device(config)# aaa local authentication default authorization default	Selects the default local authentication and authorization.
<b>Step 7</b>	<b>eap profile wcm_eap_profile</b>  <b>Example:</b> Device(config)# eap profile wcm_eap_profile	Creates an EAP profile.
<b>Step 8</b>	<b>method leap</b>  <b>Example:</b> Device(config)# method leap	Configures EAP-LEAP method on the profile.
<b>Step 9</b>	<b>end</b>  <b>Example:</b> Device(config)# end	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit the global configuration mode.

```

Device# configure terminal
Device(config)# aaa new-model
Device(config)# dot1x system-auth-control
Device(config)# aaa authentication dot1x default local
Device(config)# aaa authorization credential-download default local
Device(config)# aaa local authentication default authorization default
Device(config)# eap profile wcm_eap_profile
Device(config)# method leap
Device(config)# end

```

## Creating Client VLAN for WPA2+AES

Create a VLAN for the WPA2+AES type of local authentication. This VLAN is later mapped to a WLAN.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>vlan vlan_ID</b>  <b>Example:</b>	Creates a VLAN.

	Command or Action	Purpose
	Device (config)# vlan 105	
<b>Step 3</b>	<b>exit</b> <b>Example:</b> Device (config-vlan)# exit	Exits from the VLAN mode.
<b>Step 4</b>	<b>interface vlan <i>vlan_ID</i></b> <b>Example:</b> Device(config)# interface <b>vlan 105</b>	Associates the VLAN to the interface.
<b>Step 5</b>	<b>ip address</b> <b>Example:</b> Device(config-if)# ip address 10.8.105.10 255.255.255.0	Assigns IP address to the VLAN interface.
<b>Step 6</b>	<b>ipv6 address</b> <b>Example:</b> Device(config-if)#ipv6 address 2001:db8::10:1/64	Assigns IPv6 address to the VLAN interface.
<b>Step 7</b>	<b>exit</b> <b>Example:</b> Device (config-if)# exit	Exits from the interface mode.

```

Device# configure terminal
Device(config)# vlan105
Device (config-vlan)# exit
Device (config)# interface vlan 105
Device(config-if)#ip address 10.8.105.10 255.255.255.0
Device(config-if)#ipv6 address 2001:db8::10:1/64
Device(config-if)#exit
Device(config)#

```

## Creating WLAN for WPA2+AES

Create a WLAN and map it to the client VLAN created for WPA2+AES.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan <i>wpas2-aes-wlan 1</i></b> <b>wpas2-aes-wlan</b> <b>Example:</b>	Creates a WLAN.

	Command or Action	Purpose
	Device(config)#wlan wpa2-aes-wlan 1 wpa2-aes-wlan Device(config-wlan)#	
<b>Step 3</b>	<b>client vlan 105</b> <b>Example:</b> Device(config-wlan)#client vlan 105 Device(config-wlan)#	Maps the WLAN to the client VLAN.
<b>Step 4</b>	<b>local-auth wcm_eap_profile</b> <b>Example:</b> Device(config-wlan)#local-auth wcm_eap_profile	Creates and sets the EAP profile on the WLAN.
<b>Step 5</b>	<b>security dot1x authentication-list default</b> <b>Example:</b> Device(config-wlan)#security dot1x authentication-list default	Uses the default dot1x authentication list.
<b>Step 6</b>	<b>no shutdown</b> <b>Example:</b> Device(config-wlan)#no shutdown Device(config-wlan)#	Enables the WLAN.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

```
Device# configure terminal
Device(config)#wlan wpa2-aes-wlan 1 wpa2-aes-wlan
Device(config-wlan)#client vlan 105
Device(config-wlan)#local-auth wcm_eap_profile
Device(config-wlan)#security dot1x authentication-list default
Device(config-wlan)#no shutdown
Device(config-wlan)# exit
```

## Configuring External RADIUS Server

### Configuring RADIUS Authentication Server Host

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>radius server One</b>  <b>Example:</b> Device (config)# radius server One	Creates a radius server.
<b>Step 3</b>	<b>address ipv4 address auth-port auth_port_number acct-port acct_port_number</b>  <b>Example:</b> Device (config-radius-server)# address ipv4 10.10.10.10 auth-port 1812 acct-port 1813	Configures the IPv4 address for the radius server.
<b>Step 4</b>	<b>address ipv6 address auth-port auth_port_number acct-port acct_port_number</b>  <b>Example:</b> Device (config-radius-server)# address ipv6 2001:db8::25:2 auth-port 1812 acct-port 1813	Configures the IPv6 address for the radius server.
<b>Step 5</b>	<b>key 0 cisco</b>  <b>Example:</b> Device (config-radius-server)# key 0 cisco	<b>exit</b>
<b>Step 6</b>	<b>Example:</b> Device (config-radius-server)# exit	Exits from the radius server mode.

```

Device# configure terminal
Device (config)# radius server One
Device (config-radius-server)# address ipv4 10.10.10.10 auth-port 1812 acct-port 1813
Device (config-radius-server)# address ipv6 2001:db8::25:2 auth-port 1812 acct-port 1813
Device (config-radius-server)# key 0 cisco
Device (config-radius-server)# exit

```

## Configuring RADIUS Authentication Server Group

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>aaa new-model</b>  <b>Example:</b> Device (config)#aaa new-model	Creates a AAA authentication model.



	Command or Action	Purpose
<b>Step 3</b>	<b>aaa group server radius wcm_rad</b> <b>Example:</b> Device(config)# aaa group server radius wcm_rad Device(config-sg-radius)#	Creates an radius server-group.
<b>Step 4</b>	<b>server &lt;ip address&gt;auth-port1812acct-port1813</b> <b>Example:</b> Device(config-sg-radius)# server One auth-port 1812 acct-port 1813 Device(config-sg-radius)# server Two auth-port 1812 acct-port 1813 Device(config-sg-radius)# server Three auth-port 1812 acct-port 1813	Adds servers to the radius group created in Step 3. Configures the UDP port for RADIUS accounting server and authentication server.
<b>Step 5</b>	<b>aaa authentication dot1x method_list group wcm_rad</b> <b>Example:</b> Device(config)# aaa authentication dot1x method_list group wcm_rad	Maps the method list to the radius group.
<b>Step 6</b>	<b>dot1x system-auth-control</b> <b>Example:</b> Device(config)# dot1x system-auth-control	Enables the system authorization control for the radius group.
<b>Step 7</b>	<b>aaa session-id common</b> <b>Example:</b> Device(config)# aaa session-id common	Ensures that all session IDs information sent out, from the radius group, for a given call are identical.

```

Device# configure terminal
Device(config)# aaa new-model
Device(config)# aaa group server radius wcm_rad
Device(config-sg-radius)# server One auth-port 1812 acct-port 1813
Device(config-sg-radius)# server Two auth-port 1812 acct-port 1813
Device(config-sg-radius)# server Three auth-port 1812 acct-port 1813
Device(config)# aaa authentication dot1x method_list group wcm_rad
Device(config)# dot1x system-auth-control
Device(config)# aaa session-id common
Device(config)#

```

## Creating a Client VLAN

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>vlan 137</b> <b>Example:</b> Device(config)# vlan 137	Creates a VLAN and associate it to the interface.
<b>Step 3</b>	<b>exit</b> <b>Example:</b> Device (config-vlan)# exit	Exits from the VLAN mode.
<b>Step 4</b>	<b>interface vlan 137</b> <b>Example:</b> Device (config)# interface vlan 137	Assigns a VLAN to an interface.
<b>Step 5</b>	<b>ip address 10.7.137.10 255.255.255.0</b> <b>Example:</b> Device(config-if)# ip address 10.7.137.10 255.255.255.0	Assigns an IPv4 address to the VLAN interface.
<b>Step 6</b>	<b>ipv6 address 2001:db8::30:1/64</b> <b>Example:</b> Device(config-if)# ipv6 address 2001:db8::30:1/64	Assigns an IPv6 address to the VLAN interface.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# end	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

```
Device# configure terminal
Device(config)# vlan137
Device(config-vlan)# exit
Device(config)# interface vlan137
Device(config-if)# ip address 10.7.137.10 255.255.255.0
Device(config-if)# ipv6 address 2001:db8::30:1/64
Device(config-if)# end
```

## Creating 802.1x WLAN Using an External RADIUS Server

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan ngwc-1x&lt;ssid&gt;ngwc-1x</b> <b>Example:</b>	Creates a new WLAN for 802.1x authentication.

	Command or Action	Purpose
	Device(config)# wlan ngwc_8021x 2 ngwc_8021x	
<b>Step 3</b>	<b>broadcast-ssid</b> <b>Example:</b> Device(config-wlan)# broadcast-ssid	Configures to broadcast the SSID on WLAN.
<b>Step 4</b>	<b>no security wpa</b> <b>Example:</b> Device(config-wlan)# no security wpa	Disables the WPA for WLAN to enable 802.1x.
<b>Step 5</b>	<b>security dot1x</b> <b>Example:</b> Device(config-wlan)# security dot1x	Configures the 802.1x encryption security for the WLAN.
<b>Step 6</b>	<b>security dot1x authentication-list wcm-rad</b> <b>Example:</b> Device(config-wlan)# security dot1x authentication-list wcm-rad	Configures the server group mapping to the WLAN for dot1x authentication.
<b>Step 7</b>	<b>client vlan 137</b> <b>Example:</b> Device(config-wlan)# client vlan 137	Associates the VLAN to a WLAN.
<b>Step 8</b>	<b>no shutdown</b> <b>Example:</b> Device(config-wlan)# no shutdown	Enables the WLAN.
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device(config)# end	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit the global configuration mode.

### Example

```
Device# configure terminal
Device(config)#wlan ngwc_8021x 2 ngwc_8021x
Device(config-wlan)# broadcast-ssid
Device(config-wlan)# no security wpa
Device(config-wlan)# security dot1x
Device(config-wlan)# security dot1x authentication-list wcm-rad
Device(config-wlan)# client vlan 137
Device(config-wlan)# no shutdown
Device(config-wlan)# end
```

## Additional References

### Related Documents

Related Topic	Document Title
IPv6 command reference	<i>IPv6 Command Reference (Catalyst 3850 Switches)</i>
WLAN command reference	<i>WLAN Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>
WLAN configuration	<i>WLAN Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for IPv6 WLAN Security

This table lists the features in this module and provides links to specific configuration information:

Feature	Release	Modification
IPv6 WLAN Security Functionality	Cisco IOS XE 3.2SE	This feature was introduced.





## CHAPTER 19

# Configuring IPv6 ACL

- [Prerequisites for Configuring IPv6 ACL, on page 321](#)
- [Restrictions for Configuring IPv6 ACL, on page 321](#)
- [Information About IPv6 ACL, on page 322](#)
- [Configuring IPv6 ACLs, on page 323](#)
- [How To Configure an IPv6 ACL, on page 324](#)
- [Verifying IPv6 ACL, on page 330](#)
- [Configuration Examples for IPv6 ACL, on page 331](#)
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- [Feature Information for IPv6 ACLs, on page 336](#)

## Prerequisites for Configuring IPv6 ACL

You can filter IP Version 6 (IPv6) traffic by creating IPv6 access control lists (ACLs) and applying them to interfaces similarly to the way that you create and apply IP Version 4 (IPv4) named ACLs. You can also create and apply input router ACLs to filter Layer 3 management traffic when the switch is running the IP base feature set.

## Restrictions for Configuring IPv6 ACL

With IPv4, you can configure standard and extended numbered IP ACLs, named IP ACLs, and MAC ACLs. IPv6 supports only named ACLs.

The device supports most of the Cisco IOS-supported IPv6 ACLs with some exceptions:

- The device does not support matching on these keywords: **flowlabel**, **routing header**, and **undetermined-transport**.
- The device does not support reflexive ACLs (the **reflect** keyword).
- The device does not apply MAC-based ACLs on IPv6 frames.
- When configuring an ACL, there is no restriction on keywords entered in the ACL, regardless of whether or not they are supported on the platform. When you apply the ACL to an interface that requires hardware forwarding (physical ports or SVIs), the device checks to determine whether or not the ACL can be supported on the interface. If not, attaching the ACL is rejected.

- If an ACL is applied to an interface and you attempt to add an access control entry (ACE) with an unsupported keyword, the device does not allow the ACE to be added to the ACL that is currently attached to the interface

## Information About IPv6 ACL

An access control list (ACL) is a set of rules used to limit access to a particular interface (for example, if you want to restrict a wireless client from pinging the management interface of the controller). ACLs are configured on the device and applied to the management interface, the AP-manager interface, any of the dynamic interfaces, or a WLAN to control data traffic to and from wireless clients or to the controller central processing unit (CPU) to control all traffic destined for the CPU.

An access control list (ACL) is a set of rules used to limit access to a particular interface. ACLs are configured on the device and applied to the management interface and to any of the dynamic interfaces.

You can also create a preauthentication ACL for web authentication. Such an ACL is used to allow certain types of traffic before authentication is complete.

IPv6 ACLs support the same options as IPv4 ACLs including source, destination, source and destination ports.




---

**Note** You can enable only IPv4 traffic in your network by blocking IPv6 traffic. That is, you can configure an IPv6 ACL to deny all IPv6 traffic and apply it on specific or all WLANs.

---

## Understanding IPv6 ACLs

A switch supports two types of IPv6 ACLs:

- IPv6 router ACLs are supported on outbound or inbound traffic on Layer 3 interfaces, which can be routed ports, switch virtual interfaces (SVIs), or Layer 3 EtherChannels. IPv6 router ACLs apply only to IPv6 packets that are routed.
- IPv6 port ACLs are supported on inbound traffic on Layer 2 interfaces only. IPv6 port ACLs are applied to all IPv6 packets entering the interface.

A switch running the IP base feature set supports only input router IPv6 ACLs. It does not support port ACLs or output IPv6 router ACLs.




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**Note** If you configure unsupported IPv6 ACLs, an error message appears and the configuration does not take effect.

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The switch does not support VLAN ACLs (VLAN maps) for IPv6 traffic.

You can apply both IPv4 and IPv6 ACLs to an interface. As with IPv4 ACLs, IPv6 port ACLs take precedence over router ACLs:

- When an input router ACL and input port ACL exist in an SVI, packets received on ports to which a port ACL is applied are filtered by the port ACL. Routed IP packets received on other ports are filtered by the router ACL. Other packets are not filtered.



- When an output router ACL and input port ACL exist in an SVI, packets received on the ports to which a port ACL is applied are filtered by the port ACL. Outgoing routed IPv6 packets are filtered by the router ACL. Other packets are not filtered.



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**Note** If any port ACL (IPv4, IPv6, or MAC) is applied to an interface, that port ACL is used to filter packets, and any router ACLs attached to the SVI of the port VLAN are ignored.

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## Types of ACL

### Per User IPv6 ACL

For the per-user ACL, the full access control entries (ACE) as the text strings are configured on the ACS.

The ACE is not configured on the Controller. The ACE is sent to the device in the `ACCESS-Accept` attribute and applies it directly for the client. When a wireless client roams into an foreign device, the ACEs are sent to the foreign device as an AAA attribute in the mobility Handoff message. Output direction, using per-user ACL is not supported.

### Filter ID IPv6 ACL

For the filter-Id ACL, the full ACEs and the `acl name(filter-id)` is configured on the device and only the `filter-id` is configured on the ACS.

The `filter-id` is sent to the device in the `ACCESS-Accept` attribute, and the device looks up the `filter-id` for the ACEs, and then applies the ACEs to the client. When the client L2 roams to the foreign device, only the `filter-id` is sent to the foreign device in the mobility Handoff message. Output filtered ACL, using per-user ACL is not supported. The foreign device has to configure the `filter-id` and ACEs beforehand.

## IPv6 ACLs and Switch Stacks

The stack master supports IPv6 ACLs in hardware and distributes the IPv6 ACLs to the stack members.



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**Note** For full IPv6 functionality in a switch stack, all stack members must be running the IP services feature set.

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If a new switch takes over as stack master, it distributes the ACL configuration to all stack members. The member switches sync up the configuration distributed by the new stack master and flush out entries that member switches sync up the configuration distributed by the new stack master and flush out entries that are not required.

When an ACL is modified, attached to, or detached from an interface, the stack master distributes the change to all stack members.

## Configuring IPv6 ACLs

Follow the procedure given below to filter IPv6 traffic:

1. Create an IPv6 ACL, and enter IPv6 access list configuration mode.
2. Configure the IPv6 ACL to block (deny) or pass (permit) traffic.
3. Apply the IPv6 ACL to the interface where the traffic needs to be filtered.
4. Apply the IPv6 ACL to an interface. For router ACLs, you must also configure an IPv6 address on the Layer 3 interface to which the ACL is applied.

## Default IPv6 ACL Configuration

There are no IPv6 ACLs configured or applied.

## Interaction with Other Features and Switches

- If an IPv6 router ACL is configured to deny a packet, the packet is not routed. A copy of the packet is sent to the Internet Control Message Protocol (ICMP) queue to generate an ICMP unreachable message for the frame.
- If a bridged frame is to be dropped due to a port ACL, the frame is not bridged.
- You can create both IPv4 and IPv6 ACLs on a switch or switch stack, and you can apply both IPv4 and IPv6 ACLs to the same interface. Each ACL must have a unique name; an error message appears if you try to use a name that is already configured.

You use different commands to create IPv4 and IPv6 ACLs and to attach IPv4 or IPv6 ACLs to the same Layer 2 or Layer 3 interface. If you use the wrong command to attach an ACL (for example, an IPv4 command to attach an IPv6 ACL), you receive an error message.

- You cannot use MAC ACLs to filter IPv6 frames. MAC ACLs can only filter non-IP frames.
- If the hardware memory is full, for any additional configured ACLs, packets are dropped to the CPU, and the ACLs are applied in software. When the hardware is full a message is printed to the console indicating the ACL has been unloaded and the packets will be dropped on the interface.




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**Note** Only packets of the same type as the ACL that could not be added (ipv4, ipv6, MAC) will be dropped on the interface.

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## How To Configure an IPv6 ACL

### Creating an IPv6 ACL

#### Procedure

	Command or Action	Purpose
Step 1	enable	Enables privileged EXEC mode.

	Command or Action	Purpose
	<b>Example:</b> Device> <b>enable</b>	Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 access-list <i>acl_name</i></b> <b>Example:</b> Device# <b>ipv6 access-list access-list-name</b>	Use a name to define an IPv6 access list and enter IPv6 access-list configuration mode.
<b>Step 4</b>	<b>{deny permit} protocol</b> <b>Example:</b> <pre>{deny   permit} protocol {source-ipv6-prefix/prefix-length   any    host source-ipv6-address} [operator [port-number]]{destination-ipv6-prefix/prefix-length    any  host destination-ipv6-address} [operator [port-number]][dscp value] [fragments][log] [log-input] [routing][sequence value] [time-range name]</pre>	<p>Enter deny or permit to specify whether to deny or permit the packet if conditions are matched. These are the conditions:</p> <ul style="list-style-type: none"> <li>• For protocol, enter the name or number of an Internet protocol: ahp, esp, icmp, ipv6, pcp, stcp, tcp, or udp, or an integer in the range 0 to 255 representing an IPv6 protocol number.</li> <li>• The source-ipv6-prefix/prefix-length or destination-ipv6-prefix/ prefix-length is the source or destination IPv6 network or class of networks for which to set deny or permit conditions, specified in hexadecimal and using 16-bit values between colons (see RFC 2373).</li> <li>• Enter any as an abbreviation for the IPv6 prefix ::/0.</li> <li>• For host source-ipv6-address or destination-ipv6-address, enter the source or destination IPv6 host address for which to set deny or permit conditions, specified in hexadecimal using 16-bit values between colons.</li> <li>• (Optional) For operator, specify an operand that compares the source or destination ports of the specified protocol. Operands are lt (less than), gt (greater than), eq (equal), neq (not equal), and range.</li> </ul> <p>If the operator follows the source-ipv6-prefix/prefix-length argument, it</p>

	Command or Action	Purpose
		<p>must match the source port. If the operator follows the destination-ipv6-prefix/prefix-length argument, it must match the destination port.</p> <ul style="list-style-type: none"> <li>• (Optional) The port-number is a decimal number from 0 to 65535 or the name of a TCP or UDP port. You can use TCP port names only when filtering TCP. You can use UDP port names only when filtering UDP.</li> <li>• (Optional) Enter dscp value to match a differentiated services code point value against the traffic class value in the Traffic Class field of each IPv6 packet header. The acceptable range is from 0 to 63.</li> <li>• (Optional) Enter fragments to check noninitial fragments. This keyword is visible only if the protocol is ipv6.</li> <li>• (Optional) Enter log to cause an logging message to be sent to the console about the packet that matches the entry. Enter log-input to include the input interface in the log entry. Logging is supported only for router ACLs.</li> <li>• (Optional) Enter routing to specify that IPv6 packets be routed.</li> <li>• (Optional) Enter sequence value to specify the sequence number for the access list statement. The acceptable range is from 1 to 4294967295</li> <li>• (Optional) Enter time-range name to specify the time range that applies to the deny or permit statement.</li> </ul>
<b>Step 5</b>	<p><b>{deny permit} tcp</b></p> <p><b>Example:</b></p> <pre>{deny   permit} tcp {source-ipv6-prefix/prefix-length   any    hostsource-ipv6-address} [operator [port-number]]{destination-ipv6-prefix/prefix-length    any  hostdestination-ipv6-address} [operator [port-number]][ack] [dscp value][established] [fin]</pre>	<p>(Optional) Define a TCP access list and the access conditions.</p> <p>Enter tcp for Transmission Control Protocol. The parameters are the same as those described in Step 3, with these additional optional parameters:</p> <ul style="list-style-type: none"> <li>• ack—Acknowledgment bit set.</li> </ul>

	Command or Action	Purpose
	<pre>[log][log-input] [neq {port   protocol}] [psh] [range{port   protocol}] [rst][routing] [sequence value] [syn] [time-range name][urg]</pre>	<ul style="list-style-type: none"> <li>• established—An established connection. A match occurs if the TCP datagram has the ACK or RST bits set.</li> <li>• fin—Finished bit set; no more data from sender.</li> <li>• neq {port   protocol}—Matches only packets that are not on a given port number.</li> <li>• psh—Push function bit set.</li> <li>• range {port   protocol}—Matches only packets in the port number range.</li> <li>• rst—Reset bit set.</li> <li>• syn—Synchronize bit set.</li> <li>• urg—Urgent pointer bit set.</li> </ul>
<b>Step 6</b>	<p><b>{deny permit} udp</b></p> <p><b>Example:</b></p> <pre>{deny   permit} udp {source-ipv6-prefix/prefix-length   any   hostsource-ipv6-address} [operator [port-number]]{destination-ipv6-prefix/prefix-length   any   hostdestination-ipv6-address} [operator [port-number]][dscp value] [log][log-input] [neq {port   protocol}] [range {port   protocol}] [routing][sequence value][time-range name]</pre>	<p>(Optional) Define a UDP access list and the access conditions.</p> <p>Enter <code>udp</code> for the User Datagram Protocol. The UDP parameters are the same as those described for TCP, except that the operator <code>[port]</code> port number or name must be a UDP port number or name, and the established parameter is not valid for UDP.</p>
<b>Step 7</b>	<p><b>{deny permit} icmp</b></p> <p><b>Example:</b></p> <pre>{deny   permit} icmp {source-ipv6-prefix/prefix-length   any   hostsource-ipv6-address} [operator [port-number]] {destination-ipv6-prefix/prefix-length   any   hostdestination-ipv6-address} [operator [port-number]][icmp-type [icmp-code]  icmp-message] [dscpvalue] [log] [log-input] [routing] [sequence value][time-range name]</pre>	<p>(Optional) Define an ICMP access list and the access conditions.</p> <p>Enter <code>icmp</code> for Internet Control Message Protocol. The ICMP parameters are the same as those described for most IP protocols in Step 3a, with the addition of the ICMP message type and code parameters. These optional keywords have these meanings:</p> <ul style="list-style-type: none"> <li>• <code>icmp-type</code>—Enter to filter by ICMP message type, a number from 0 to 255.</li> <li>• <code>icmp-code</code>—Enter to filter ICMP packets that are filtered by the ICMP message code type, a number from 0 to 255.</li> <li>• <code>icmp-message</code>—Enter to filter ICMP packets by the ICMP message type name</li> </ul>

	Command or Action	Purpose
		or the ICMP message type and code name. To see a list of ICMP message type names and code names, use the ? key or see command reference for this release.
<b>Step 8</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 9</b>	<b>show ipv6 access-list</b> <b>Example:</b> show ipv6 access-list	Verify the access list configuration.
<b>Step 10</b>	<b>copy running-config startup-config</b> <b>Example:</b> copy running-config startup-config	(Optional) Save your entries in the configuration file.

## Applying an IPv6 to an Interface

This section describes how to apply IPv6 ACLs to network interfaces. You can apply an IPv6 ACL to outbound or inbound traffic on layer 2 and Layer 3 interfaces. You can apply IPv6 ACLs only to inbound management traffic on Layer 3 interfaces.

To control access to an interface, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface_id</i></b> <b>Example:</b> Device# <b>interface interface-id</b>	Identifies a Layer 2 interface (for port ACLs) or Layer 3 Switch Virtual interface (for router ACLs) on which to apply an access list, and enters interface configuration mode.

	Command or Action	Purpose
<b>Step 4</b>	<b>no switchport</b> <b>Example:</b> Device# <b>no switchport</b>	Changes the interface from Layer 2 mode (the default) to Layer 3 mode (only if applying a router ACL).
<b>Step 5</b>	<b>ipv6 address ipv6_address</b> <b>Example:</b> Device# <b>ipv6 address ipv6-address</b>	Configures an IPv6 address on a Layer 3 interface (for router ACLs).  <b>Note</b> This command is not required on Layer 2 interfaces or if the interface has already been configured with an explicit IPv6 address.
<b>Step 6</b>	<b>ipv6 traffic-filter acl_name</b> <b>Example:</b> Device# <b>ipv6 traffic-filter access-list-name {in   out}</b>	Applies the access list to incoming or outgoing traffic on the interface.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 8</b>	<b>show running-config interface tenGigabitEthernet 1/0/3</b> <b>Example:</b> Device# show running-config interface tenGigabitEthernet 1/0/3 ..... ..... Building configuration ....., ..... Current configuration : 98 bytes ! interface TenGigabitEthernet1/0/3 switchport mode trunk ipv6 traffic-filter MyFilter out end	Shows the configuration summary.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b> copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Creating WLAN IPv6 ACL

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>ipv6 traffic-filter acl <i>acl_name</i></b> <b>Example:</b> Device(config-wlan)# ipv6 traffic-filter acl testacl	Creates a named WLAN ACL.
<b>Step 2</b>	<b>ipv6 traffic-filter acl web</b> <b>Example:</b> Device(config-wlan)# ipv6 traffic-filter acl web testacl	Creates a pre-authentication for WLAN ACL.

## Verifying IPv6 ACL

### Displaying IPv6 ACLs

To display IPv6 ACLs, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>show access-list</b> <b>Example:</b> Device# <b>show access-lists</b>	Displays all access lists configured on the device
<b>Step 4</b>	<b>show ipv6 access-list <i>acl_name</i></b> <b>Example:</b> Device# <b>show ipv6 access-list</b> [ <i>access-list-name</i> ]	Displays all configured IPv6 access list or the access list specified by name.



# Configuration Examples for IPv6 ACL

## Example: Creating an IPv6 ACL

This example configures the IPv6 access list named CISCO. The first deny entry in the list denies all packets that have a destination TCP port number greater than 5000. The second deny entry denies packets that have a source UDP port number less than 5000. The second deny also logs all matches to the console. The first permit entry in the list permits all ICMP packets. The second permit entry in the list permits all other traffic. The second permit entry is necessary because an implicit deny -all condition is at the end of each IPv6 access list.



**Note** Logging is supported only on Layer 3 interfaces.

```
Device(config)# ipv6 access-list CISCO
Device(config-ipv6-acl)# deny tcp any any gt 5000
Device (config-ipv6-acl)# deny ::/0 lt 5000 ::/0 log
Device(config-ipv6-acl)# permit icmp any any
Device(config-ipv6-acl)# permit any any
```

## Example: Applying IPv6 ACLs

This example shows how to apply the access list Cisco to outbound traffic on a Layer 3 interface.

```
Device(config)# interface TenGigabitEthernet 1/0/3

Device(config-if)# no switchport
Device(config-if)# ipv6 address 2001::/64 eui-64
Device(config-if)# ipv6 traffic-filter CISCO out
```

## Example: Displaying IPv6 ACLs

This is an example of the output from the **show access-lists** privileged EXEC command. The output shows all access lists that are configured on the switch or switch stack.

```
Device #show access-lists
Extended IP access list hello
10 permit ip any any
IPv6 access list ipv6
permit ipv6 any any sequence 10
```

This is an example of the output from the **show ipv6 access-lists** privileged EXEC command. The output shows only IPv6 access lists configured on the switch or switch stack.

```
Device# show ipv6 access-list
IPv6 access list inbound
permit tcp any any eq bgp (8 matches) sequence 10
permit tcp any any eq telnet (15 matches) sequence 20
permit udp any any sequence 30

IPv6 access list outbound
deny udp any any sequence 10
deny tcp any any eq telnet sequence 20
```

## Example: Configuring RA Throttling and NS Suppression

This task describes how to create an RA throttle policy in order to help the power-saving wireless clients from being disturbed by frequent unsolicited periodic RA's. The unsolicited multicast RA is throttled by the controller.

### Before you begin

Enable IPv6 on the client machine.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ipv6 nd ra-throttler policy Mythrottle</b> <b>Example:</b> Device (config)# <code>ipv6 nd ra-throttler policy Mythrottle</code>	Creates a RA throttler policy called Mythrottle.
<b>Step 3</b>	<b>throttle-period 20</b> <b>Example:</b> Device (config-nd-ra-throttle)# <code>throttle-period 20</code>	Determines the time interval segment during which throttling applies.
<b>Step 4</b>	<b>max-through 5</b> <b>Example:</b> Device (config-nd-ra-throttle)# <code>max-through 5</code>	Determines how many initial RA's are allowed.
<b>Step 5</b>	<b>allow at-least 3 at-most 5</b> <b>Example:</b> Device (config-nd-ra-throttle)# <code>allow at-least 3 at-most 5</code>	Determines how many RA's are allowed after the initial RAs have been transmitted, until the end of the interval segment.
<b>Step 6</b>	<b>switch (config)# vlan configuration 100</b> <b>Example:</b> Device (config)# <code>vlan configuration 100</code>	Creates a per vlan configuration.
<b>Step 7</b>	<b>ipv6 nd suppress</b> <b>Example:</b> Device (config)# <code>ipv6 nd suppress</code>	Disables the neighbor discovery on the Vlan.
<b>Step 8</b>	<b>ipv6 nd ra-th attach-policy attach-policy_name</b> <b>Example:</b>	Enables the router advertisement throttling.

	Command or Action	Purpose
	Device (config)# ipv6 nd ra-throttle attach-policy attach-policy_name	
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring RA Guard Policy

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 nd rguard policy <i>policy name</i></b> <b>Example:</b> Device(config)# <b>ipv6 nd rguard policy</b> <b>MyPolicy</b>	
<b>Step 4</b>	<b>trusted-port</b> <b>Example:</b> Device(config-nd-rguard)# <b>trusted-port</b>	Configures the trusted port for the policy created above.
<b>Step 5</b>	<b>device-role router</b> <b>Example:</b> Device(config-nd-rguard)# <b>device-role</b> <b>[host monitor router switch]</b> Device(config-nd-rguard)# <b>device-role</b> <b>router</b> <b>d</b>	Defines the trusted device that can send RAs to the trusted port created above.
<b>Step 6</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface</b> <b>tenGigabitEthernet 1/0/1</b>	Configures the interface to the trusted device.
<b>Step 7</b>	<b>ipv6 nd rguard attach-policy <i>policy name</i></b> <b>Example:</b>	Configures and attaches the policy to trust the RA's received from the port.

	Command or Action	Purpose
	<code>Device(config-if)# ipv6 nd raguard attach-policy Mypolicy</code>	
<b>Step 8</b>	<code>vlan <i>vlan-id</i></code> <b>Example:</b> <code>Device(config)# vlan configuration 19-21,23</code>	Configures the wireless client vlans.
<b>Step 9</b>	<code>ipv6 nd suppress</code> <b>Example:</b> <code>Device(config-vlan-config)# ipv6 nd suppress</code>	Suppresses the ND messages over wireless.
<b>Step 10</b>	<code>ipv6 snooping</code> <b>Example:</b> <code>Device(config-vlan-config)# ipv6 snooping</code>	Captures IPv6 traffic.
<b>Step 11</b>	<code>ipv6 nd raguard attach-policy <i>policy name</i></code> <b>Example:</b> <code>Device(config-vlan-config)# ipv6 nd raguard attach-policy Mypolicy</code>	Attaches the RA Guard policy to the wireless client vlans.
<b>Step 12</b>	<code>ipv6 nd ra-throttler attach-policy <i>policy name</i></code> <b>Example:</b> <code>Device(config-vlan-config)# ipv6 nd ra-throttler attach-policy Mythrottle</code>	Attaches the RA throttling policy to the wireless client vlans.

## Configuring IPv6 Neighbor Binding

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>enable</code> <b>Example:</b> <code>Device&gt; enable</code>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<code>configure terminal</code> <b>Example:</b> <code>Device# configure terminal</code>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<pre> <b>ipv6 neighbor binding [vlan] 19</b> <b>2001:db8::25:4 interface</b> <b>tenGigabitEthernet 1/0/3 aaa.bbb.ccc</b>  <b>Example:</b>  Device(config)# <b>ipv6 neighbor binding</b> <b>vlan 19 2001:db8::25:4 interface</b> <b>tenGigabitEthernet 1/0/3 aaa.bbb.ccc</b> </pre>	Sets and validates the neighbor 2001:db8::25:4 only valid when transmitting on VLAN 19 through interface te1/0/3 with the source mac-address as aaa.bbb.ccc.

## Additional References

### Related Documents

#### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for IPv6 ACLs

This table lists the features in this module and provides links to specific configuration information:

Feature	Release	Modification
IPv6 ACL Functionality	Cisco IOS XE 3.2SE	This feature was introduced.
Downloadable IPv6 ACL	Cisco IOS XE Gibraltar 16.11.1	This feature was introduced.



## CHAPTER 20

# Configuring IPv6 Web Authentication

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- [Prerequisites for IPv6 Web Authentication, on page 337](#)
- [Restrictions for IPv6 Web Authentication, on page 337](#)
- [Information About IPv6 Web Authentication, on page 338](#)
- [How to Configure IPv6 Web Authentication, on page 339](#)
- [Verifying IPv6 Web Authentication, on page 344](#)
- [Additional References , on page 345](#)
- [Feature Information for IPv6 Web Authentication, on page 346](#)

## Prerequisites for IPv6 Web Authentication

The following configurations must be in place before you start with IPv6 Web Authentication:

- IPv6 Device Tracking.
- IPv6 DHCP Snooping.
- Disable security of type 802.1x on the wlan.
- Each WLAN must have a vlan associated to it.
- Change the default wlan setting from **shutdown** to **no shutdown**.

### Related Topics

[Enabling Security on the WLAN, on page 340](#)

## Restrictions for IPv6 Web Authentication

The following restrictions are implied when using IPv6 web authentication:

### Related Topics

[Enabling Security on the WLAN, on page 340](#)

## Information About IPv6 Web Authentication

Web authentication is a Layer 3 security feature and the device disallows IP traffic (except DHCP and DNS -related packets) from a particular client until it supplies a valid username and password. It is a simple authentication method without the need for a supplicant or client utility. Web authentication is typically used by customers who deploy a guest-access network. Traffic from both, HTTP and HTTPS, page is allowed to display the login page.




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**Note** Web authentication does not provide data encryption and is typically used as simple guest access for either a hot spot or campus atmosphere, where connectivity is always a factor.

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A WLAN is configured as **security webauth** for web based authentication. The device supports the following types of web based authentication:

- Web Authentication – The client enters the credentials in a web page which is then validated by the Wlan controller.
- Web Consent – The Wlan controller presents a policy page with Accept/Deny buttons. Click Accept button to access the network.




---

**Note** Maximum consecutive Web Auth sessions supported in device is 40 per second.

---

A Wlan is typically configured for open authentication, that is without Layer 2 authentication, when web-based authentication mechanism is used.

## Web Authentication Process

The following events occur when a WLAN is configured for web authentication:

- The user opens a web browser and enters a URL address, for example, *http://www.example.com*. The client sends out a DNS request for this URL to get the IP address for the destination. The device bypasses the DNS request to the DNS server, which in turn responds with a DNS reply that contains the IP address of the destination *www.example.com*. This, in turn, is forwarded to the wireless clients.
- The client then tries to open a TCP connection with the destination IP address. It sends out a TCP SYN packet destined to the IP address of *www.example.com*.
- The device has rules configured for the client and cannot act as a proxy for *www.example.com*. It sends back a TCP SYN-ACK packet to the client with source as the IP address of *www.example.com*. The client sends back a TCP ACK packet in order to complete the three-way TCP handshake and the TCP connection is fully established.
- The client sends an HTTP GET packet destined to *www.example.com*. The device intercepts this packet and sends it for redirection handling. The HTTP application gateway prepares an HTML body and sends it back as the reply to the HTTP GET requested by the client. This HTML makes the client go to the default web-page of the device, for example, *http://<Virtual-Server-IP>/login.html*.
- The client closes the TCP connection with the IP address, for example, *www.example.com*.



- If the client wants to go to virtual IP, the client tries to open a TCP connection with the virtual IP address of the device. It sends a TCP SYN packet for virtual IP to the device.
- The device responds back with a TCP SYN-ACK and the client sends back a TCP ACK to the device in order to complete the handshake.
- The client sends an HTTP GET for */login.html* destined to virtual IP in order to request for the login page.
- This request is allowed to the web server of the device, and the server responds with the default login page. The client receives the login page in the browser window where the user can log in.

### Related Topics

[Disabling WPA](#), on page 339

[Enabling Security on the WLAN](#), on page 340

[Enabling a Parameter Map on the WLAN](#), on page 341

[Enabling Authentication List on WLAN](#), on page 341

[Configuring a Global WebAuth WLAN Parameter Map](#), on page 341

[Configuring the WLAN](#), on page 342

[Enabling IPv6 in Global Configuration Mode](#), on page 343

[Verifying the Parameter Map](#), on page 344

[Verifying Authentication List](#), on page 344

# How to Configure IPv6 Web Authentication

## Disabling WPA

### Before you begin

Disable 802.1x. A typical web authentication does not use Layer 2 security. Use this configuration to remove Layer 2 security.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan test1 2 test1</b> <b>Example:</b> Device(config)# <b>wlan test1 2 test1</b>	Creates a WLAN and assign an SSID to it.

	Command or Action	Purpose
<b>Step 3</b>	<b>no security wpa</b>  <b>Example:</b> Device(config-wlan)# no security wpa	Disables the WPA support for Wlan.

**What to do next**

Enable the following:

- Security Web Authentication.
- Parameter Local.
- Authentication List.

**Related Topics**

[Web Authentication Process](#), on page 338

## Enabling Security on the WLAN

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>parameter-map type web-auth global</b>  <b>Example:</b> Device(config)# parameter-map type web-auth global	Applies the parameter map to all the web-auth wlangs.
<b>Step 2</b>	<b>virtual-ip ipv4 192.0.2.1</b>  <b>Example:</b> Device(config-params-parameter-map)# virtual-ip ipv4 192.0.2.1	Defines the virtual gateway IPv4 address.
<b>Step 3</b>	<b>virtual-ip ipv6 2001:db8::24:2</b>  <b>Example:</b> Device(config-params-parameter-map)# virtual-ip ipv6 2001:db8::24:2	Defines the virtual gateway IPv6 address.

**Related Topics**

[Prerequisites for IPv6 Web Authentication](#), on page 337

[Restrictions for IPv6 Web Authentication](#), on page 337

[Web Authentication Process](#), on page 338

## Enabling a Parameter Map on the WLAN

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>security web-auth parameter-map</b> <b>&lt;mapname&gt;</b>  <b>Example:</b> Device(config-wlan)# security web-auth parameter-map webparalocal	Enables web authentication for the wlan and creates a parameter map.

### Related Topics

[Web Authentication Process](#), on page 338

## Enabling Authentication List on WLAN

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>security web-auth authentication-list</b> <b>webauthlistlocal</b>  <b>Example:</b> Device(config-wlan)# security web-auth	Enables web authentication for the wlan and creates a local web authentication list.

### Related Topics

[Web Authentication Process](#), on page 338

## Configuring a Global WebAuth WLAN Parameter Map

Use this example to configure a global web auth WLAN and add a parameter map to it.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>parameter-map type webauth global</b>  <b>Example:</b> Device (config)# parameter-map type webauth global	Configures a global webauth and adds a parameter map to it.
<b>Step 2</b>	<b>virtual-ip ipv6 2001 : db8 : 4 : : 1</b>  <b>Example:</b> Device (config-params-parameter-map)# virtual-ip ipv6 2001:db8:4::1	Defines a virtual gateway IP address that appears to the wireless clients for authentication.

	Command or Action	Purpose
<b>Step 3</b>	<b>ratelimit init-state-sessions 120</b> <b>Example:</b> Device (config-params-parameter-map)# ratelimit init-state-sessions 120	Sets the global ratelimit to limit the bandwidth that the web clients can use on the device to avoid over-flooding attacks.
<b>Step 4</b>	<b>max-https-conns 70</b> <b>Example:</b> Device (config-params-parameter-map)# max-http-conns 70	Sets the maximum number of attempted http connections on the device to avoid over-flooding attacks.

**Related Topics**

[Web Authentication Process](#), on page 338

[Configuring the WLAN](#), on page 342

## Configuring the WLAN

**Before you begin**

- The WLAN must have a Vlan associated with it. By default, a new Wlan is always associated with Vlan 1, which can be changed as per the configuration requirements.
- Configure and enable the WLAN to *no shutdown*. By default, the Wlan is configured with the *shutdown* parameter and is disabled.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>wlan <i>l</i></b> <b>Example:</b> Device(config-wlan)# wlan 1 name vicweb ssid vicweb	Creates a wlan and assign an SSID to it.
<b>Step 2</b>	<b>client vlan <i>interface ID</i></b> <b>Example:</b> Device(config-wlan)# client vlan VLAN0136	Assigns the client to vlan interface.
<b>Step 3</b>	<b>security web-auth authentication list webauthlistlocal</b> <b>Example:</b> Device(config-wlan)# security web-auth authentication-list webauthlistlocal	Configures web authentication for the wlan.
<b>Step 4</b>	<b>security web-auth parameter-map global</b> <b>Example:</b>	Configures the parameter map on the wlan.

	Command or Action	Purpose
	Device(config-wlan)# security web-auth parameter-map global	
<b>Step 5</b>	<b>no security wpa</b> <b>Example:</b> Device(config-wlan)# no security wpa	Configures the security policy for a wlan. This enables the wlan.
<b>Step 6</b>	<b>no shutdown</b> <b>Example:</b> Device(config-wlan)# no shutdown	Configures and enables the Wlan.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# end	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

**Related Topics**

[Configuring a Global WebAuth WLAN Parameter Map](#), on page 341

[Web Authentication Process](#), on page 338

[Enabling IPv6 in Global Configuration Mode](#), on page 343

## Enabling IPv6 in Global Configuration Mode

Enable IPv6 in global configuration for web authentication.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>web-auth global</b> <b>Example:</b> Device(config)# parameter-map type webauth global	Globally configures the parameter map type as web authentication.
<b>Step 3</b>	<b>virtual IPv6</b> <b>Example:</b> Device(config-params-parameter-map)# virtual-ip ipv6	Selects IPv6 as the virtual IP for web authentication.  <b>Note</b> You can also select IPv4 as the preferred IP for web authentication.

**Related Topics**

[Configuring the WLAN](#), on page 342

[Web Authentication Process](#), on page 338

[Verifying the Parameter Map](#), on page 344

# Verifying IPv6 Web Authentication

## Verifying the Parameter Map

Use the **show running configuration** command to verify the parameter map configured for Wlan.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>show running config</b>  <b>Example:</b> Device#show running config	Displays the entire running configuration for the device. Grep for parameter map to view the result.

```
wlan alpha 2 alpha
no security wpa
no security wpa akm dot1x
no security wpa wpa2
no security wpa wpa2 ciphers aes
security web-auth
security web-auth authentication-list webauthlistlocal
security web-auth parameter-map webparalocal
```

### Related Topics

[Enabling IPv6 in Global Configuration Mode](#), on page 343

[Web Authentication Process](#), on page 338

[Verifying Authentication List](#), on page 344

## Verifying Authentication List

Use the **show running configuration** command to verify the authentication list configured for the Wlan.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>show running configuration</b>  <b>Example:</b> Device#show running-config	Displays the Wlan configuration.  Device# show running-config
<b>Step 2</b>	<b>end</b>  <b>Example:</b> Device (config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

```
Device#show running-config
.....
.....
```

```

.....
wlan alpha 2 alpha
no security wpa
no security wpa akm dot1x
no security wpa wpa2
no security wpa wpa2 ciphers aes
security web-auth
security web-auth authentication-list webauthlistlocal
security web-auth parameter-map webparalocal
.....
.....
.....

```

### Related Topics

[Verifying the Parameter Map](#), on page 344

[Web Authentication Process](#), on page 338

## Additional References

### Related Documents

Related Topic	Document Title
IPv6 command reference	<i>IPv6 Command Reference (Catalyst 3850 Switches)</i>
Web Authentication configuration	<i>Security Configuration Guide (Catalyst 3850 Switches)</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for IPv6 Web Authentication

This table lists the features in this module and provides links to specific configuration information:

Feature	Release	Modification
IPv6 Web Authentication Functionality	Cisco IOS XE 3.2SE	This feature was introduced.





## CHAPTER 21

# IPv6 Client Mobility

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- [Prerequisites for IPv6 Client Mobility, on page 347](#)
- [Restrictions For IPv6 Client Mobility, on page 347](#)
- [Information About IPv6 Client Mobility, on page 347](#)
- [Verifying IPv6 Client Mobility, on page 350](#)
- [Monitoring IPv6 Client Mobility, on page 351](#)
- [Additional References, on page 351](#)
- [Feature Information for IPv6 Client Mobility, on page 352](#)

## Prerequisites for IPv6 Client Mobility

- To enable wireless IPv6 client connectivity, the underlying wired network must support IPv6 routing and an address assignment mechanism such as SLAAC or DHCPv6. The device must have L2 adjacency to the IPv6 router, and the VLAN needs to be tagged when the packets enter the device. APs do not require connectivity on an IPv6 network, as all traffic is encapsulated inside the IPv4 CAPWAP tunnel between the AP and device.

## Restrictions For IPv6 Client Mobility

- When using the IPv6 Client Mobility, clients must support IPv6 with either static stateless auto configuration (such as Windows XP clients) or stateful DHCPv6 IP addressing (such as Windows 7 clients).
- To allow smooth operation of stateful DHCPv6 IP addressing, you must have a switch or router that supports the DHCP for IPv6 feature (such as the device) that is configured to act like a DHCPv6 server, or you need a dedicated server such as a Windows 2008 server with a built-in DHCPv6 server.

## Information About IPv6 Client Mobility

The Device supports IPv6 mobility for IPv6-only or dual-stack nodes. The IPv6 Client Mobility is divided into:

- Link Layer and

- Network Layer

The link layer is handled by the 802.11 protocol which enables the client to roam to any AP in the same BSS (basic service set) identified by the same SSID without losing the link layer connectivity.

However, link layer mobility is not enough to make wireless client Layer 3 applications continue to work seamlessly while roaming. Cisco IOSd's wireless mobility module uses mobility tunneling to retain seamless connectivity for the client's Layer 3 PoP (point of presence) when the client roams across different subnets on different switches.

IPv6 is the next-generation network layer Internet protocol intended to replace IPv4 in the TCP/IP suite of protocols. This new version increases the internet global address space to accommodate users and applications that require unique global IP addresses. IPv6 incorporates 128-bit source and destination addresses, which provide significantly more addresses than the 32-bit IPv4 addresses.

To support IPv6 clients across controllers, ICMPv6 messages must be dealt with specially to ensure the IPv6 client remains on the same Layer 3 network. The device keeps track of IPv6 clients by intercepting the ICMPv6 messages to provide seamless mobility and protect the network from network attacks. The NDP (neighbor discovery packets) packets are converted from multicast to unicast and delivered individually per client. This unique solution ensures that Neighbor Discovery and Router Advertisement packets are not leaked across VLANs. Clients can receive specific Neighbor Discovery and Router Advertisement packets ensuring correct IPv6 addressing to avoid unnecessary multicast traffic.

The configuration for IPv6 mobility is the same as IPv4 mobility and requires no separate software on the client side to achieve seamless roaming. The device must be part of the same mobility group. Both IPv4 and IPv6 client mobility are enabled by default.

IPv6 client mobility is used for the following:

- Retaining the client IPv6 multiple addresses in Layer-2 and Layer-3 roaming.
- IPv6 Neighbor Discovery Protocol (NDP) packet management.
- Client IPv6 addresses learning.


**Note**

The configuration for IPv6 mobility in SDA wireless and Local mode is the same as of IPv4 mobility and requires no different software configuration on the client side to achieve seamless roaming. Refer to IPv4 mobility section for configuration information.

## Using Router Advertisement

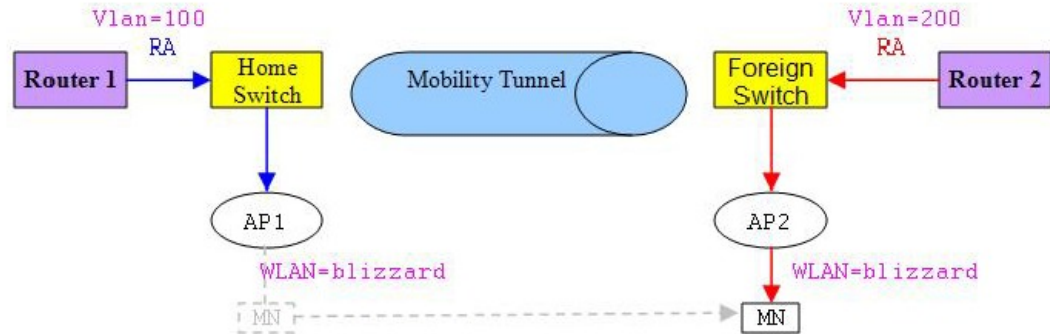
The Neighbor Discovery Protocol (NDP) operates in the link-layer and is responsible for the discovery of other nodes on the link. It determines the link-layer addresses of other nodes, finds the available routers, and maintains reachability information about the paths to other active neighbor nodes.

Router Advertisement (RA) is one of the IPv6 Neighbor Discovery Protocol (NDP) packets that is used by the hosts to discover available routers, acquire the network prefix to generate the IPv6 addresses, link MTU, and so on. The routers send RA on a regular basis, or in response to hosts Router Solicitation messages.

IPv6 wireless client mobility manages the IPv6 RA packet. The converged access device forwards the link-local all-nodes multicast RA packets to the local and roaming wireless nodes mapped on same VLAN the RA was received on.

Figure 1 illustrates the link-local all-nodes mcst RA forwarding issue in the wireless node mobility.

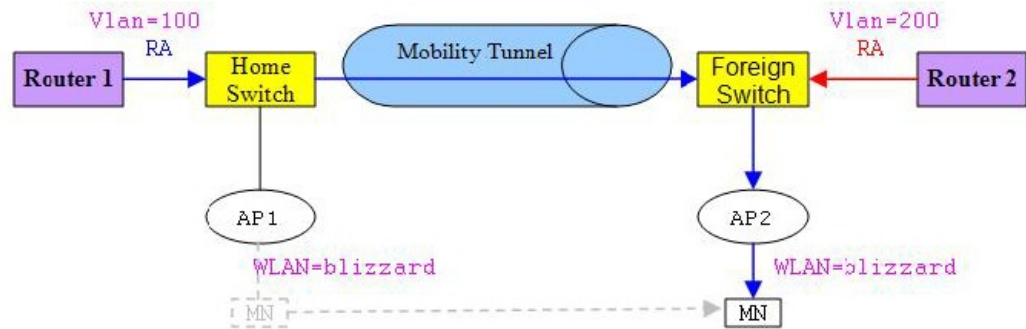
**Figure 14: Roaming Client Receiving Invalid RA from Router 2**



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Figure 2 illustrates how a roaming client “MN” receives RA from VLAN 200 in a foreign switch and how it acquires a new IP address and breaks into L3 mobility's point of presence.

**Figure 15: Roaming Client Receives Valid RA from Router 1**



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## RA Throttling and NS suppression

To safeguard the power-saving wireless clients from being disturbed by frequent unsolicited periodic RAs, the controller can throttle the unsolicited multicast RA.

## IPv6 Address Learning

There are three ways for IPv6 client to acquire IPv6 addresses:

- Stateless Address Auto-Configuration (SLAAC)
- Stateful DHCPv6
- Static configuration

For these methods, the IPv6 client always sends NS DAD (duplicate address detection) to ensure that there is no duplicated IP address on the network. The device snoops the clients NDP and DHCPv6 packets to learn about its client IP addresses and then updates the controllers database. The database then informs the controller for the clients new IP address.

## Handling Multiple IP Addresses

In the case when the new IP address is received after RUN state, whether an addition or removal, the controller updates the new IP addresses on its local database for display purposes. Essentially, the IPv6 uses the existing or same PEM state machine code flow as in IPv4. When the IP addresses are requested by external entities, for example, from Prime Infrastructure, the controller will include all the available IP addresses, IPv4 and IPv6, in the API/SPI interface to the external entities.

An IPv6 client can acquire multiple IP addresses from stack for different purposes. For example, a link-local address for link local traffic, and a routable unique local or global address.

When the client is in the DHCP request state and the controller receives the first IP address notification from the database for either an IPv4 or IPv6 address, the PEM moves the client into the RUN state.

When a new IP address is received after the RUN state, either for addition or removal, the controller updates the new IP addresses on its local database for display purposes.

When the IP addresses are requested by external entities, for example, from Prime Infrastructure, the controller provides the available IP addresses, both IPv4 and IPv6, to the external entities.

## IPv6 Configuration

The device supports IPv6 client as seamlessly as the IPv4 clients. The administrator must manually configure the VLANs to enable the IPv6, IPv6's snooping and throttling functionality. This will enable the NDP packets to throttle between the device and its various clients.

## High Availability

The switch will sync with the wireless clients when the clients IP address is hard to learn. When a switchover happens, the IPv6 neighbor binding table is synced to standby state. However, the wireless client will itself disassociate and reassociate to a new active state once the switchover is complete and the neighbor binding table is updated with latest information for that client.

If, during the reassociation, the client moves to another AP then the original entry in the binding table is marked as down for sometime and will be aged-out.

For the new entries joining the switch from another AP, the new IP address is learned and notified to the controller's database.




---

**Note** This feature is available only for the Cisco Catalyst 3850 Switch.

---

## Verifying IPv6 Client Mobility

The commands listed in the Table 1 applies to the IPv6 client mobility.

*Table 25: Commands for Verifying IPv6 Client Mobility on Cisco 5760 WLC*

Command	Description

<b>debug mobility ipv6</b>	Enables all the wireless client IPv6 mobility debugs.
<b>debug client mac-address (mac-addr)</b>	Displays wireless client debugging. Enter a MAC address for debugging information.

## Monitoring IPv6 Client Mobility

The commands in Table 2 are used to monitor IPv6 Client mobility on the device.

**Table 26: Monitoring IPv6 Client Mobility Commands**

Commands	Description
<b>show wireless client summary</b>	Displays the wireless specific configuration of active clients.
<b>show wireless client mac-address (mac-addr)</b>	Displays the wireless specific configuration of active clients based on their MAC address.

## Additional References

### Related Documents

Related Topic	Document Title
IPv6 command reference	<i>IPv6 Command Reference (Catalyst 3850 Switches)</i>
Mobility configuration	<i>Mobility Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for IPv6 Client Mobility

This table lists the features in this module and provides links to specific configuration information:

Feature	Release	Modification
IPv6 Client Mobility Functionality	Cisco IOS XE 3.2SE	This feature was introduced.



## CHAPTER 22

# Configuring IPv6 Mobility

- [Pre-requisites for IPv6 Mobility, on page 353](#)
- [Information About IPv6 Mobility, on page 353](#)
- [How to Configure IPv6 Mobility, on page 354](#)
- [Monitoring IPv6 Mobility, on page 354](#)
- [Additional References, on page 356](#)
- [Feature Information for IPv6 Mobility, on page 357](#)

## Pre-requisites for IPv6 Mobility

The mobility and its related infrastructure must be configured and ready for use.

## Information About IPv6 Mobility

Mobility, or roaming, is a wireless LAN client's ability to maintain its association seamlessly from one access point to another securely and with as little latency as possible. This section explains how mobility works when devices are included in a wireless network.

When a wireless client associates and authenticates to an access point, the access point's device places an entry for that client in its client database. This entry includes the client's MAC and IP addresses, security context and associations, quality of service (QoS) contexts, the WLAN, and the associated access point. The device uses this information to forward frames and manage traffic to and from the wireless client.

When the wireless client moves its association from one access point to another, the device simply updates the client database with the newly associated access point. If necessary, new security context and associations are established as well. The process becomes more complicated, however, when a client roams from an access point joined to one device to an access point joined to a different device. It also varies based on whether the devices are operating on the same subnet.

## Inter Controller Roaming

When the client associates to an access point joined to a new device, the new device exchanges mobility messages with the original device, and the client database entry is moved to the new device if sticky anchoring is disabled.

**Related Topics**

[Monitoring IPv6 Mobility](#), on page 354

## Intra Subnet Roaming with Sticky Anchoring, and Inter Subnet Roaming

Inter-subnet roaming is similar to inter-controller roaming in that the device exchange mobility messages on the client roam. However, instead of moving the client database entry to the new device, the original device marks the client with an "Anchor" entry in its own client database. The database entry is copied to the new device client database and marked with a "Foreign" entry in the new device. The roam remains transparent to the wireless client, and the client maintains its original IP address.

In inter-subnet roaming, WLANs on both anchor and foreign device need to have the same network access privileges and no source-based routing or source-based firewalls in place. Otherwise, the clients may have network connectivity issues after the handoff.

For more information on configuring mobility see, the Cisco 5700 Wireless LAN Controller Mobility Configuration Guide, Cisco IOS XE, Release 3.2SE.

**Related Topics**

[Monitoring IPv6 Mobility](#), on page 354

## How to Configure IPv6 Mobility

### Monitoring IPv6 Mobility

This chapter displays the mobility related IPv6 configuration. To see the mobility related configurations refer to the Cisco 5700 Wireless LAN Controller Mobility Configuration Guide, Cisco IOS XE 3.2SE.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>show ipv6 neighbors binding mac C0C1 . C06B . C4E2</b>  <b>Example:</b> Device# show ipv6 neighbors binding mac C0C1.C06B.C4E2	Displays the IPv6 related mobility configurations.

**Example**

```
Device# show ipv6 neighbors binding mac C0C1.C06B.C4E2
Binding Table has 45 entries, 37 dynamic (limit 100)
Codes: L - Local, S - Static, ND - Neighbor Discovery, DH - DHCP, PKT - Other Packet, API
- API created
Preflevel flags (prlvl):
0001:MAC and LLA match      0002:Orig trunk           0004:Orig access
0008:Orig trusted trunk    0010:Orig trusted access  0020:DHCP assigned
0040:Cga authenticated     0080:Cert authenticated   0100:Statically assigned
```



IPv6 address	Link-Layer addr	Interface	vlan	prlvl	age
state Time left					
L FE80:20:25::16	2037.064C.BA71	V125	25	0100	3137mn
REACHABLE					
L FE80:20:24::16	2037.064C.BA41	V124	24	0100	3137mn
REACHABLE					
L FE80:20:23::16	2037.064C.BA44	V123	23	0100	3137mn
REACHABLE					
ND FE80:20:23::13	2037.0653.6BC4	Te1/0/1	23	0005	85s
REACHABLE 223 s try 0					
ND FE80:20:22::17	2037.064D.06F6	Te1/0/1	22	0005	3mn
REACHABLE 92 s try 0					
L FE80:20:22::16	2037.064C.BA76	V122	22	0100	3137mn
REACHABLE					
ND FE80:20:22::13	2037.0653.6BF6	Te1/0/1	22	0005	165s
REACHABLE 136 s try 0					
ND FE80:20:22::12	2037.064C.94F6	Te1/0/1	22	0005	23s
REACHABLE 281 s try 0					
ND FE80:20:22::2	0022.550E.8FC3	Te1/0/1	22	0005	18s
REACHABLE 295 s try 0					
ND FE80:20:21::17	2037.064D.06E8	Te1/0/1	21	0005	4mn
REACHABLE 60 s try 0					
L FE80:20:21::16	2037.064C.BA68	V121	21	0100	3137mn
REACHABLE					
ND FE80:20:21::13	2037.0653.6BE8	Te1/0/1	21	0005	57s
REACHABLE 252 s try 0					
ND FE80:20:21::12	2037.064C.94E8	Te1/0/1	21	0005	4s
REACHABLE 297 s					
ND FE80:20:21::2	0022.550E.8FC2	Te1/0/1	21	0005	2s
REACHABLE 307 s try 0					
ND FE80::F866:8BE0:12E4:39CF	C0C1.C06B.C4E2	Ca4	21	0005	3mn
REACHABLE 89 s try 0					
ND FE80::6D0A:DB33:D69E:91C7	0050.B606.A6CE	Te1/0/1	22	0005	135s
REACHABLE 171 s try 0					
ND FE80::985:8189:9937:BB05	8CA9.8295.09CC	Ca0	21	0005	15s
REACHABLE 287 s					
ND FE80::20:24:13	2037.0653.6BC1	Te1/0/1	24	0005	155s
REACHABLE 145 s try 0					
L 2001:20:23::16	2037.064C.BA44	V123	23	0100	3137mn
REACHABLE					
DH 2001:20:22:0:C96C:AF29:5DDC:2689	0050.B606.A6CE	Te1/0/1	22	0024	19s
REACHABLE 286 s try 0(16574)					
DH 2001:20:22:0:A46B:90B2:F0DB:F952	0050.B606.A6CE	Te1/0/1	22	0024	2339mn
STALE 32401 s					
DH 2001:20:22:0:7DFD:14EC:B1E4:1172	0050.B606.A6CE	Te1/0/1	22	0024	2339mn
STALE 24394 s					
DH 2001:20:22:0:7CB3:D6DD:FD6A:50F	0050.B606.A6CE	Te1/0/1	22	0024	2333mn
STALE 29195 s					
DH 2001:20:22:0:6D32:AF24:FDE1:2504	0050.B606.A6CE	Te1/0/1	22	0024	509mn
STALE 118821 s					
DH 2001:20:22:0:5106:5AD:FE98:A2F0	0050.B606.A6CE	Te1/0/1	22	0024	2328mn
STALE 31362 s					
ND 2001:20:22::201:13	0050.B606.A6CE	Te1/0/1	22	0005	49s
REACHABLE 264 s try 0					
L 2001:20:22::16	2037.064C.BA76	V122	22	0100	3137mn
REACHABLE					
ND 2001:20:22::13	2037.0653.6BF6	Te1/0/1	22	0005	175s
REACHABLE 131 s try 0					
ND 2001:20:22::2	0022.550E.8FC3	Te1/0/1	22	0005	28s
REACHABLE 274 s try 0					
ND 2001:20:21:0:F866:8BE0:12E4:39CF	C0C1.C06B.C4E2	Ca4	21	0005	4mn
REACHABLE 21 s try 0					
ND 2001:20:21:0:C085:9D4C:4521:B777	0021.CC73.AA17	Te1/0/1	21	0005	11s
REACHABLE 290 s try 0					

```

ND 2001:20:21:0:6233:4BFF:FE1A:744C      6033.4B1A.744C Ca4      21 0005 3mn
REACHABLE 108 s try 0
ND 2001:20:21:0:447E:745D:2F48:1C68      8CA9.8295.09CC Ca0      21 0005 34s
REACHABLE 276 s
ND 2001:20:21:0:3920:DDE8:B29:AD51        C0C1.C06B.C4E2 Ca4      21 0005 3mn
REACHABLE 87 s try 0
ND 2001:20:21:0:1016:A333:FAD5:6E66        0021.CC73.AA17 Te1/0/1  21 0005 4mn
REACHABLE 18 s try 0
ND 2001:20:21:0:C42:E317:BA9B:EB17        6033.4B1A.744C Ca4      21 0005 4mn
REACHABLE 61 s try 0
ND 2001:20:21:0:985:8189:9937:BB05        8CA9.8295.09CC Ca0      21 0005 135s
REACHABLE 173 s try 0
ND 2001:20:21::201:20                      0021.CC73.AA17 Te1/0/1  21 0005 4mn
REACHABLE 43 s try 0
ND 2001:20:21::17                          2037.064D.06E8 Te1/0/1  21 0005 4mn
REACHABLE 50 s try 0
L 2001:20:21::16                          2037.064C.BA68 V121     21 0100 3137mn
REACHABLE
ND 2001:20:21::13                          2037.0653.6BE8 Te1/0/1  21 0005 67s
REACHABLE 237 s try 0
ND 2001:20:21::12                          2037.064C.94E8 Te1/0/1  21 0005 5mn
REACHABLE 512 ms try 0
ND 2001:20:21::2                          0022.550E.8FC2 Te1/0/1  21 0005 12s
REACHABLE 294 s try 0

```

**Related Topics**

[Inter Controller Roaming](#), on page 353

[Intra Subnet Roaming with Sticky Anchoring, and Inter Subnet Roaming](#), on page 354

# Additional References

**Related Documents**

Related Topic	Document Title
IPv6 command reference	<i>IPv6 Command Reference (Catalyst 3850 Switches)</i>
Mobility configurations	<i>Mobility Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>

**Error Message Decoder**

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<p><a href="http://www.cisco.com/support">http://www.cisco.com/support</a></p>

## Feature Information for IPv6 Mobility

This table lists the features in this module and provides links to specific configuration information:

Feature	Release	Modification
IPv6 Mobility Functionality	Cisco IOS XE 3.2SE	This feature was introduced.





# PART VI

## IP

- [Configuring HSRP, on page 361](#)
- [Configuring NHRP, on page 383](#)
- [VRRPv3 Protocol Support, on page 393](#)
- [Configuring GLBP, on page 407](#)





## CHAPTER 23

# Configuring HSRP

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- [Configuring HSRP](#) , on page 361

## Configuring HSRP

This chapter describes how to use Hot Standby Router Protocol (HSRP) to provide routing redundancy for routing IP traffic without being dependent on the availability of any single router.

You can also use a version of HSRP in Layer 2 mode to configure a redundant command switch to take over cluster management if the cluster command switch fails.

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Configuring HSRP

### HSRP Overview

HSRP is Cisco's standard method of providing high network availability by providing first-hop redundancy for IP hosts on an IEEE 802 LAN configured with a default gateway IP address. HSRP routes IP traffic without relying on the availability of any single router. It enables a set of router interfaces to work together to present the appearance of a single virtual router or default gateway to the hosts on a LAN. When HSRP is configured on a network or segment, it provides a virtual Media Access Control (MAC) address and an IP address that is shared among a group of configured routers. HSRP allows two or more HSRP-configured routers to use the MAC address and IP network address of a virtual router. The virtual router does not exist; it represents the common target for routers that are configured to provide backup to each other. One of the routers is selected to be the active router and another to be the standby router, which assumes control of the group MAC address and IP address should the designated active router fail.



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**Note** Routers in an HSRP group can be any router interface that supports HSRP, including routed ports and switch virtual interfaces (SVIs).

---

HSRP provides high network availability by providing redundancy for IP traffic from hosts on networks. In a group of router interfaces, the active router is the router of choice for routing packets; the standby router is the router that takes over the routing duties when an active router fails or when preset conditions are met.

HSRP is useful for hosts that do not support a router discovery protocol and cannot switch to a new router when their selected router reloads or loses power. When HSRP is configured on a network segment, it provides a virtual MAC address and an IP address that is shared among router interfaces in a group of router interfaces running HSRP. The router selected by the protocol to be the active router receives and routes packets destined for the group's MAC address. For  $n$  routers running HSRP, there are  $n + 1$  IP and MAC addresses assigned.

HSRP detects when the designated active router fails, and a selected standby router assumes control of the Hot Standby group's MAC and IP addresses. A new standby router is also selected at that time. Devices running HSRP send and receive multicast UDP-based hello packets to detect router failure and to designate active and standby routers. When HSRP is configured on an interface, Internet Control Message Protocol (ICMP) redirect messages are automatically enabled for the interface.

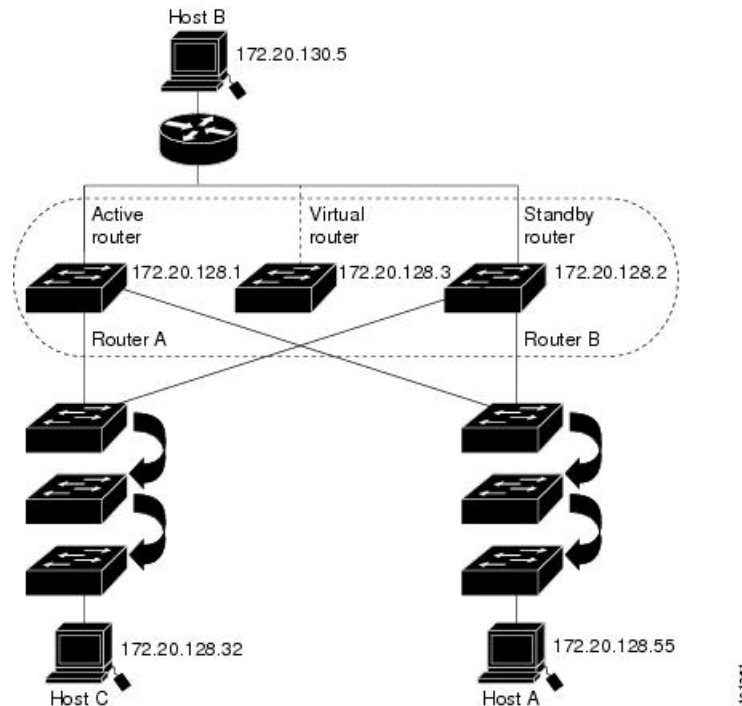
You can configure multiple Hot Standby groups among switches and switch stacks that are operating in Layer 3 to make more use of the redundant routers.

To do so, specify a group number for each Hot Standby command group you configure for an interface. For example, you might configure an interface on switch 1 as an active router and one on switch 2 as a standby router and also configure another interface on switch 2 as an active router with another interface on switch 1 as its standby router.

The following figure shows a segment of a network configured for HSRP. Each router is configured with the MAC address and IP network address of the virtual router. Instead of configuring hosts on the network with the IP address of Router A, you configure them with the IP address of the virtual router as their default router. When Host C sends packets to Host B, it sends them to the MAC address of the virtual router. If for any reason, Router A stops transferring packets, Router B responds to the virtual IP address and virtual MAC address and becomes the active router, assuming the active router duties. Host C continues to use the IP address of the virtual router to address packets destined for Host B, which Router B now receives and sends to Host B. Until Router A resumes operation, HSRP allows Router B to provide uninterrupted service to users on Host C's segment that need to communicate with users on Host B's segment and also continues to perform its normal function of handling packets between the Host A segment and Host B.



Figure 16: Typical HSRP Configuration



## HSRP Versions

Cisco IOS XE 3.3SE and later support these Hot Standby Router Protocol (HSRP) versions:

The switch supports these HSRP versions:

- HSRPv1- Version 1 of the HSRP, the default version of HSRP. It has these features:
  - The HSRP group number can be from 0 to 255.
  - HSRPv1 uses the multicast address 224.0.0.2 to send hello packets, which can conflict with Cisco Group Management Protocol (CGMP) leave processing. You cannot enable HSRPv1 and CGMP at the same time; they are mutually exclusive.
- HSRPv2- Version 2 of the HSRP has these features:
  - HSRPv2 uses the multicast address 224.0.0.102 to send hello packets. HSRPv2 and CGMP leave processing are no longer mutually exclusive, and both can be enabled at the same time.
  - HSRPv2 has a different packet format than HSRPv1.
  - The HSRP group number can be from 0 to 4095.

A switch running HSRPv1 cannot identify the physical router that sent a hello packet because the source MAC address of the router is the virtual MAC address.

HSRPv2 has a different packet format than HSRPv1. A HSRPv2 packet uses the type-length-value (TLV) format and has a 6-byte identifier field with the MAC address of the physical router that sent the packet.

If an interface running HSRPv1 gets an HSRPv2 packet, the type field is ignored.

## Multiple HSRP

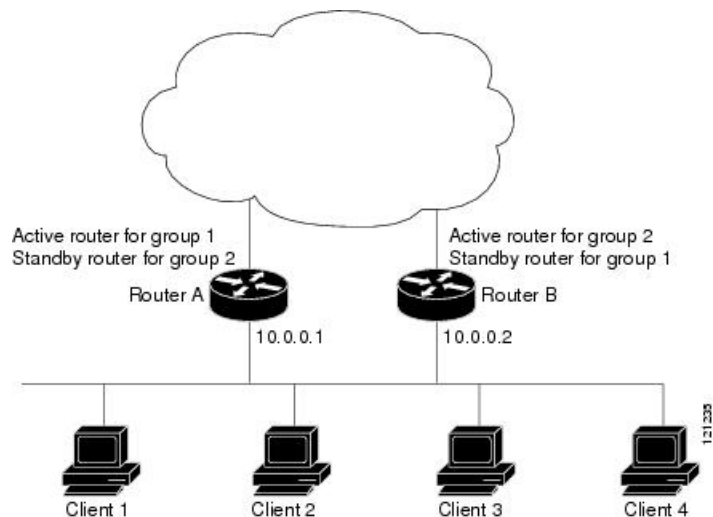
The switch supports Multiple HSRP (MHSRP), an extension of HSRP that allows load sharing between two or more HSRP groups. You can configure MHSRP to achieve load-balancing and to use two or more standby groups (and paths) from a host network to a server network.

In the figure below, half the clients are configured for Router A, and half the clients are configured for Router B. Together, the configuration for Routers A and B establishes two HSRP groups. For group 1, Router A is the default active router because it has the assigned highest priority, and Router B is the standby router. For group 2, Router B is the default active router because it has the assigned highest priority, and Router A is the standby router. During normal operation, the two routers share the IP traffic load. When either router becomes unavailable, the other router becomes active and assumes the packet-transfer functions of the router that is unavailable.



**Note** For MHSRP, you need to enter the **standby preempt** interface configuration command on the HSRP interfaces so that if a router fails and then comes back up, preemption restores load sharing.

**Figure 17: MHSRP Load Sharing**



## SSO HSRP

SSO HSRP alters the behavior of HSRP when a device with redundant Route Processors (RPs) is configured for stateful switchover (SSO) redundancy mode. When an RP is active and the other RP is standby, SSO enables the standby RP to take over if the active RP fails.

With this functionality, HSRP SSO information is synchronized to the standby RP, allowing traffic that is sent using the HSRP virtual IP address to be continuously forwarded during a switchover without a loss of data or a path change. Additionally, if both RPs fail on the active HSRP device, then the standby HSRP device takes over as the active HSRP device.

The feature is enabled by default when the redundancy mode of operation is set to SSO.

## HSRP and Switch Stacks

HSRP hello messages are generated by the stack master. If an HSRP-active stack master fails, a flap in the HSRP active state might occur. This is because HSRP hello messages are not generated while a new stack master is elected and initialized, and the standby router might become active after the stack master fails.

## Configuring HSRP for IPv6

Switches running the IP Services and IP Base feature set support the Hot Standby Router Protocol (HSRP) for IPv6. HSRP provides routing redundancy for routing IPv6 traffic not dependent on the availability of any single router. IPv6 hosts learn of available routers through IPv6 neighbor discovery router advertisement messages. These messages are multicast periodically or are solicited by hosts.

An HSRP IPv6 group has a virtual MAC address that is derived from the HSRP group number and a virtual IPv6 link-local address that is, by default, derived from the HSRP virtual MAC address.

Periodic messages are sent for the HSRP virtual IPv6 link-local address when the HSRP group is active. These messages stop after a final one is sent when the group leaves the active state.




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**Note** When configuring HSRP for IPv6, you must enable HSRP version 2 (HSRPv2) on the interface.

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## How to Configure HSRP

### Default HSRP Configuration

*Table 27: Default HSRP Configuration*

Feature	Default Setting
HSRP version	Version 1
HSRP groups	None configured
Standby group number	0
Standby MAC address	System assigned as: 0000.0c07.acXX, where XX is the HSRP group number
Standby priority	100
Standby delay	0 (no delay)
Standby track interface priority	10
Standby hello time	3 seconds
Standby holdtime	10 seconds

### HSRP Configuration Guidelines

- HSRPv2 and HSRPv1 are mutually exclusive. HSRPv2 is not interoperable with HSRPv1 on an interface and the reverse.

- In the procedures, the specified interface must be one of these Layer 3 interfaces:
  - Routed port: A physical port configured as a Layer 3 port by entering the **no switchport** command in interface configuration mode.
  - SVI: A VLAN interface created by using the **interface vlan** *vlan\_id* in global configuration mode, and by default a Layer 3 interface.
  - Etherchannel port channel in Layer 3 mode: A port-channel logical interface created by using the **interface port-channel** *port-channel-number* in global configuration mode, and binding the Ethernet interface into the channel group.
- All Layer 3 interfaces must have IP addresses assigned to them.
- If you change the HSRP version on an interface, each HSRP group resets because it now has a new virtual MAC address.
- Only on mixed stacks of Catalyst switches:
  - HSRP for IPv4 and HSRP for IPv6 are mutually exclusive. You cannot enable both at the same time.
  - When configuring group numbers for HSRPv2 and HSRP, you must use group numbers in ranges that are multiples of 256. Valid ranges are 0 to 255, 256 to 511, 512 to 767, 3840 to 4095, and so on.
  - Examples of valid and invalid group numbers:
    - If you configure groups with the numbers 2, 150, and 225, you cannot configure another group with the number 3850. It is not in the range of 0 to 255.
    - If you configure groups with the numbers 520, 600, and 700, you cannot configure another group with the number 900. It is not in the range of 512 to 767.



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**Note** You can configure up to 128 groups at the configuration level but the recommended HSRP group number limit is 64.

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**Note** HSRP millisecond timers are not supported.

---

## Enabling HSRP

The **standby ip** interface configuration command activates HSRP on the configured interface. If an IP address is specified, that address is used as the designated address for the Hot Standby group. If no IP address is specified, the address is learned through the standby function. You must configure at least one Layer 3 port on the LAN with the designated address. Configuring an IP address always overrides another designated address currently in use.

When the **standby ip** command is enabled on an interface and proxy ARP is enabled, if the interface's Hot Standby state is active, proxy ARP requests are answered using the Hot Standby group MAC address. If the interface is in a different state, proxy ARP responses are suppressed.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Switch(config)# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Switch(config)# <b>interface</b> <b>gigabitethernet1/0/1</b>	Enters interface configuration mode, and enter the Layer 3 interface on which you want to enable HSRP.
<b>Step 3</b>	<b>standby version { 1   2 }</b> <b>Example:</b> Switch(config-if)# <b>standby version 1</b>	(Optional) Configures the HSRP version on the interface.  <ul style="list-style-type: none"> <li>• 1- Selects HSRPv1.</li> <li>• 2- Selects HSRPv2.</li> </ul> <p>If you do not enter this command or do not specify a keyword, the interface runs the default HSRP version, HSRP v1.</p>
<b>Step 4</b>	<b>standby [<i>group-number</i>] ip [<i>ip-address</i> [<i>secondary</i>]]</b> <b>Example:</b> Switch(config-if)# <b>standby 1 ip</b>	Creates (or enable) the HSRP group using its number and virtual IP address.  <ul style="list-style-type: none"> <li>• (Optional) <i>group-number</i>- The group number on the interface for which HSRP is being enabled. The range is 0 to 255; the default is 0. If there is only one HSRP group, you do not need to enter a group number.</li> <li>• (Optional on all but one interface) <i>ip-address</i>- The virtual IP address of the hot standby router interface. You must enter the virtual IP address for at least one of the interfaces; it can be learned on the other interfaces.</li> <li>• (Optional) <b>secondary</b>- The IP address is a secondary hot standby router interface. If neither router is designated as a secondary or standby router and no priorities are set, the primary IP addresses are compared and the higher IP address is the active router, with the next highest as the standby router.</li> </ul>
<b>Step 5</b>	<b>end</b> <b>Example:</b> Switch(config-if)# <b>end</b>	Returns to privileged EXEC mode

	Command or Action	Purpose
<b>Step 6</b>	<b>show standby</b> [ <i>interface-id</i> [ <i>group</i> ] ] <b>Example:</b> Switch # <b>show standby</b>	Verifies the configuration of the standby groups.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Switch# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring HSRP Priority

The **standby priority**, **standby preempt**, and **standby track** interface configuration commands are all used to set characteristics for finding active and standby routers and behavior regarding when a new active router takes over.

When configuring HSRP priority, follow these guidelines:

- Assigning a priority allows you to select the active and standby routers. If preemption is enabled, the router with the highest priority becomes the active router. If priorities are equal, the current active router does not change.
- The highest number (1 to 255) represents the highest priority (most likely to become the active router).
- When setting the priority, preempt, or both, you must specify at least one keyword (**priority**, **preempt**, or both)
- The priority of the device can change dynamically if an interface is configured with the **standby track** command and another interface on the router goes down.
- The **standby track** interface configuration command ties the router hot standby priority to the availability of its interfaces and is useful for tracking interfaces that are not configured for HSRP. When a tracked interface fails, the hot standby priority on the device on which tracking has been configured decreases by 10. If an interface is not tracked, its state changes do not affect the hot standby priority of the configured device. For each interface configured for hot standby, you can configure a separate list of interfaces to be tracked
- The **standby track interface-priority** interface configuration command specifies how much to decrement the hot standby priority when a tracked interface goes down. When the interface comes back up, the priority is incremented by the same amount.
- When multiple tracked interfaces are down and *interface-priority* values have been configured, the configured priority decrements are cumulative. If tracked interfaces that were not configured with priority values fail, the default decrement is 10, and it is noncumulative.
- When routing is first enabled for the interface, it does not have a complete routing table. If it is configured to preempt, it becomes the active router, even though it is unable to provide adequate routing services. To solve this problem, configure a delay time to allow the router to update its routing table.

Beginning in privileged EXEC mode, use one or more of these steps to configure HSRP priority characteristics on an interface:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Switch # <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Switch(config)# <b>interface</b> <b>gigabitethernet1/0/1</b>	Enters interface configuration mode, and enter the HSRP interface on which you want to set priority.
<b>Step 3</b>	<b>standby [<i>group-number</i>] <b>priority</b><i>priority</i></b> <b>Example:</b> Switch(config-if)# <b>standby 120 priority</b> <b>50</b>	<p>Sets a <b>priority</b> value used in choosing the active router. The range is 1 to 255; the default priority is 100. The highest number represents the highest priority.</p> <ul style="list-style-type: none"> <li>• (Optional) <b>group-number</b>—The group number to which the command applies.</li> </ul> <p>Use the <b>no</b> form of the command to restore the default values.</p>
<b>Step 4</b>	<b>standby [<i>group-number</i>] <b>preempt</b> [<b>delay</b> [<b>minimumseconds</b>] [<b>reloadseconds</b>] [<b>syncseconds</b>]]</b> <b>Example:</b> Switch(config-if)# <b>standby 1 preempt</b> <b>delay 300</b>	<p>Configures the router to <b>preempt</b>, which means that when the local router has a higher priority than the active router, it becomes the active router.</p> <ul style="list-style-type: none"> <li>• (Optional) <b>group-number</b>—The group number to which the command applies.</li> <li>• (Optional) <b>delay minimum</b>—Set to cause the local router to postpone taking over the active role for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over).</li> <li>• (Optional) <b>delay reload</b>—Set to cause the local router to postpone taking over the active role after a reload for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over after a reload).</li> <li>• (Optional) <b>delay sync</b>—Set to cause the local router to postpone taking over the active role so that IP redundancy clients can reply (either with an ok or wait reply) for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over).</li> </ul> <p>Use the <b>no</b> form of the command to restore the default values.</p>

	Command or Action	Purpose
<b>Step 5</b>	<b>standby</b> [ <i>group-number</i> ] <b>track</b> <i>type number</i> [ <i>interface-priority</i> ]  <b>Example:</b> Switch(config-if) # <b>standby track</b> <b>interface</b> gigabitethernet1/1/1	Configures an interface to track other interfaces so that if one of the other interfaces goes down, the device's Hot Standby priority is lowered. <ul style="list-style-type: none"> <li>• (Optional) <i>group-number</i>- The group number to which the command applies.</li> <li>• <i>type</i>- Enter the interface type (combined with interface number) that is tracked.</li> <li>• <i>number</i>- Enter the interface number (combined with interface type) that is tracked.</li> <li>• (Optional) <i>interface-priority</i>- Enter the amount by which the hot standby priority for the router is decremented or incremented when the interface goes down or comes back up. The default value is 10.</li> </ul>
<b>Step 6</b>	<b>end</b>  <b>Example:</b>  Switch(config-if) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show running-config</b>	Verifies the configuration of the standby groups.
<b>Step 8</b>	<b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring MHSRP

To enable MHSRP and load-balancing, you configure two routers as active routers for their groups, with virtual routers as standby routers as shown in the *MHSRP Load Sharing* figure in the Multiple HSRP section. You need to enter the **standby preempt** interface configuration command on each HSRP interface so that if a router fails and comes back up, the preemption occurs and restores load-balancing.

Router A is configured as the active router for group 1, and Router B is configured as the active router for group 2. The HSRP interface for Router A has an IP address of 10.0.0.1 with a group 1 standby priority of 110 (the default is 100). The HSRP interface for Router B has an IP address of 10.0.0.2 with a group 2 standby priority of 110.

Group 1 uses a virtual IP address of 10.0.0.3 and group 2 uses a virtual IP address of 10.0.0.4.

### Configuring Router A

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Switch # <b>configure terminal</b>	Enters global configuration mode.



	Command or Action	Purpose
<b>Step 2</b>	<b>interface</b> <i>type number</i> <b>Example:</b> Switch (config)# <b>interface</b> <b>gigabitethernet1/0/1</b>	Configures an interface type and enters interface configuration mode.
<b>Step 3</b>	<b>no switchport</b> <b>Example:</b> Switch (config)# <b>no switchport</b>	Switches an interface that is in Layer 2 mode into Layer 3 mode for Layer 3 configuration.
<b>Step 4</b>	<b>ip address</b> <i>ip-address mask</i> <b>Example:</b> Switch (config-if)# <b>ip address</b> 10.0.0.1 255.255.255.0	Specifies an IP address for an interface.
<b>Step 5</b>	<b>standby</b> [ <i>group-number</i> ] <b>ip</b> [ <i>ip-address</i> ] [ <i>secondary</i> ] <b>Example:</b> Switch (config-if)# <b>standby 1 ip</b> 10.0.0.3	Creates the HSRP group using its number and virtual IP address. <ul style="list-style-type: none"> <li>• (Optional) <i>group-number</i>- The group number on the interface for which HSRP is being enabled. The range is 0 to 255; the default is 0. If there is only one HSRP group, you do not need to enter a group number.</li> <li>• (Optional on all but one interface) <i>ip-address</i>- The virtual IP address of the hot standby router interface. You must enter the virtual IP address for at least one of the interfaces; it can be learned on the other interfaces.</li> <li>• (Optional) <b>secondary</b>- The IP address is a secondary hot standby router interface. If neither router is designated as a secondary or standby router and no priorities are set, the primary IP addresses are compared and the higher IP address is the active router, with the next highest as the standby router.</li> </ul>
<b>Step 6</b>	<b>standby</b> [ <i>group-number</i> ] <b>priority</b> <i>priority</i> <b>Example:</b> Switch(config-if)# <b>standby 1 priority</b> 110	Sets a <b>priority</b> value used in choosing the active router. The range is 1 to 255; the default priority is 100. The highest number represents the highest priority. <ul style="list-style-type: none"> <li>• (Optional) <i>group-number</i>—The group number to which the command applies.</li> </ul> Use the <b>no</b> form of the command to restore the default values.

	Command or Action	Purpose
Step 7	<p><b>standby</b> [<i>group-number</i>] <b>preempt</b> [<b>delay</b> [<b>minimum</b> <i>seconds</i>] [<b>reload</b> <i>seconds</i>] [<b>sync</b> <i>seconds</i>]]</p> <p><b>Example:</b></p> <pre>Switch(config-if)# standby 1 preempt delay 300</pre>	<p>Configures the router to <b>preempt</b>, which means that when the local router has a higher priority than the active router, it becomes the active router.</p> <ul style="list-style-type: none"> <li>• (Optional) <b>group-number</b>—The group number to which the command applies.</li> <li>• (Optional) <b>delay minimum</b>—Set to cause the local router to postpone taking over the active role for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over).</li> <li>• (Optional) <b>delay reload</b>—Set to cause the local router to postpone taking over the active role after a reload for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over after a reload).</li> <li>• (Optional) <b>delay sync</b>—Set to cause the local router to postpone taking over the active role so that IP redundancy clients can reply (either with an ok or wait reply) for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over).</li> </ul> <p>Use the <b>no</b> form of the command to restore the default values.</p>
Step 8	<p><b>standby</b> [<i>group-number</i>] <b>ip</b> [<i>ip-address</i>] [<b>secondary</b>]]</p> <p><b>Example:</b></p> <pre>Switch (config-if)# standby 2 ip 10.0.0.4</pre>	<p>Creates the HSRP group using its number and virtual IP address.</p> <ul style="list-style-type: none"> <li>• (Optional) <i>group-number</i>— The group number on the interface for which HSRP is being enabled. The range is 0 to 255; the default is 0. If there is only one HSRP group, you do not need to enter a group number.</li> <li>• (Optional on all but one interface) <i>ip-address</i>— The virtual IP address of the hot standby router interface. You must enter the virtual IP address for at least one of the interfaces; it can be learned on the other interfaces.</li> <li>• (Optional) <b>secondary</b>— The IP address is a secondary hot standby router interface. If neither router is designated as a secondary or standby router and no</li> </ul>

	Command or Action	Purpose
		priorities are set, the primary IP addresses are compared and the higher IP address is the active router, with the next highest as the standby router.
<b>Step 9</b>	<p><b>standby</b> [<i>group-number</i>] <b>preempt</b> [<b>delay</b> [<i>minimum seconds</i>] [<b>reload</b> <i>seconds</i>] [<b>sync</b> <i>seconds</i>]]</p> <p><b>Example:</b></p> <pre>Switch(config-if)# standby 2 preempt delay 300</pre>	<p>Configures the router to <b>preempt</b>, which means that when the local router has a higher priority than the active router, it becomes the active router.</p> <ul style="list-style-type: none"> <li>• (Optional) <b>group-number</b>—The group number to which the command applies.</li> <li>• (Optional) <b>delay minimum</b>—Set to cause the local router to postpone taking over the active role for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over).</li> <li>• (Optional) <b>delay reload</b>—Set to cause the local router to postpone taking over the active role after a reload for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over after a reload).</li> <li>• (Optional) <b>delay sync</b>—Set to cause the local router to postpone taking over the active role so that IP redundancy clients can reply (either with an ok or wait reply) for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over).</li> </ul> <p>Use the <b>no</b> form of the command to restore the default values.</p>
<b>Step 10</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Switch(config-if)# end</pre>	Returns to privileged EXEC mode.
<b>Step 11</b>	<b>show running-config</b>	Verifies the configuration of the standby groups.
<b>Step 12</b>	<b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring Router B

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Switch # <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>type number</i></b> <b>Example:</b> Switch (config)# <b>interface gigabitethernet1/0/1</b>	Configures an interface type and enters interface configuration mode.
<b>Step 3</b>	<b>no switchport</b> <b>Example:</b> Switch (config)# <b>no switchport</b>	Switches an interface that is in Layer 2 mode into Layer 3 mode for Layer 3 configuration.
<b>Step 4</b>	<b>ip address <i>ip-address mask</i></b> <b>Example:</b> Switch (config-if)# <b>10.0.0.2 255.255.255.0</b>	Specifies an IP address for an interface.
<b>Step 5</b>	<b>standby [<i>group-number</i>] ip [<i>ip-address</i> [<i>secondary</i>]]</b> <b>Example:</b> Switch (config-if)# <b>standby 1 ip 10.0.0.3</b>	Creates the HSRP group using its number and virtual IP address. <ul style="list-style-type: none"> <li>• (Optional) <i>group-number</i>- The group number on the interface for which HSRP is being enabled. The range is 0 to 255; the default is 0. If there is only one HSRP group, you do not need to enter a group number.</li> <li>• (Optional on all but one interface) <i>ip-address</i>- The virtual IP address of the hot standby router interface. You must enter the virtual IP address for at least one of the interfaces; it can be learned on the other interfaces.</li> <li>• (Optional) <b>secondary</b>- The IP address is a secondary hot standby router interface. If neither router is designated as a secondary or standby router and no priorities are set, the primary IP addresses are compared and the higher IP address is the active router, with the next highest as the standby router.</li> </ul>
<b>Step 6</b>	<b>standby [<i>group-number</i>] <b>priority</b> <i>priority</i></b> <b>Example:</b>	Sets a <b>priority</b> value used in choosing the active router. The range is 1 to 255; the default

	Command or Action	Purpose
	Switch(config-if)# <b>standby 1 priority 110</b>	<p>priority is 100. The highest number represents the highest priority.</p> <ul style="list-style-type: none"> <li>• (Optional) <i>group-number</i>—The group number to which the command applies.</li> </ul> <p>Use the <b>no</b> form of the command to restore the default values.</p>
<b>Step 7</b>	<p><b>standby</b> [<i>group-number</i>] <b>preempt</b> [<b>delay</b> [<i>minimum seconds</i>] [<b>reload</b> <i>seconds</i>] [<b>sync</b> <i>seconds</i>]]</p> <p><b>Example:</b></p> <pre>Switch(config-if)# standby 1 preempt delay 300</pre>	<p>Configures the router to <b>preempt</b>, which means that when the local router has a higher priority than the active router, it becomes the active router.</p> <ul style="list-style-type: none"> <li>• (Optional) <i>group-number</i>—The group number to which the command applies.</li> <li>• (Optional) <b>delay minimum</b>—Set to cause the local router to postpone taking over the active role for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over).</li> <li>• (Optional) <b>delay reload</b>—Set to cause the local router to postpone taking over the active role after a reload for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over after a reload).</li> <li>• (Optional) <b>delay sync</b>—Set to cause the local router to postpone taking over the active role so that IP redundancy clients can reply (either with an ok or wait reply) for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over).</li> </ul> <p>Use the <b>no</b> form of the command to restore the default values.</p>
<b>Step 8</b>	<p><b>standby</b> [<i>group-number</i>] <b>ip</b> [<i>ip-address</i>] [<b>secondary</b>]]</p> <p><b>Example:</b></p> <pre>Switch (config-if)# standby 2 ip 10.0.0.4</pre>	<p>Creates the HSRP group using its number and virtual IP address.</p> <ul style="list-style-type: none"> <li>• (Optional) <i>group-number</i>—The group number on the interface for which HSRP is being enabled. The range is 0 to 255; the default is 0. If there is only one HSRP group, you do not need to enter a group number.</li> <li>• (Optional on all but one interface) <i>ip-address</i>—The virtual IP address of the hot standby router interface. You must</li> </ul>

	Command or Action	Purpose
		<p>enter the virtual IP address for at least one of the interfaces; it can be learned on the other interfaces.</p> <ul style="list-style-type: none"> <li>• (Optional) <b>secondary</b>- The IP address is a secondary hot standby router interface. If neither router is designated as a secondary or standby router and no priorities are set, the primary IP addresses are compared and the higher IP address is the active router, with the next highest as the standby router.</li> </ul>
<b>Step 9</b>	<p><b>standby</b> [<i>group-number</i>] <b>preempt</b> [<b>delay</b> [<b>minimum</b> <i>seconds</i>] [<b>reload</b> <i>seconds</i>] [<b>sync</b> <i>seconds</i>] ]</p> <p><b>Example:</b></p> <pre>Switch(config-if)# standby 2 preempt delay 300</pre>	<p>Configures the router to <b>preempt</b>, which means that when the local router has a higher priority than the active router, it becomes the active router.</p> <ul style="list-style-type: none"> <li>• (Optional) <b>group-number</b>-The group number to which the command applies.</li> <li>• (Optional) <b>delay minimum</b>—Set to cause the local router to postpone taking over the active role for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over).</li> <li>• (Optional) <b>delay reload</b>—Set to cause the local router to postpone taking over the active role after a reload for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over after a reload).</li> <li>• (Optional) <b>delay sync</b>—Set to cause the local router to postpone taking over the active role so that IP redundancy clients can reply (either with an ok or wait reply) for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over).</li> </ul> <p>Use the <b>no</b> form of the command to restore the default values.</p>
<b>Step 10</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Switch(config-if)# end</pre>	Returns to privileged EXEC mode.
<b>Step 11</b>	<b>show running-config</b>	Verifies the configuration of the standby groups.

	Command or Action	Purpose
Step 12	<code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring HSRP Authentication and Timers

You can optionally configure an HSRP authentication string or change the hello-time interval and holdtime.

When configuring these attributes, follow these guidelines:

- The authentication string is sent unencrypted in all HSRP messages. You must configure the same authentication string on all routers and access servers on a cable to ensure interoperability. Authentication mismatch prevents a device from learning the designated Hot Standby IP address and timer values from other routers configured with HSRP.
- Routers or access servers on which standby timer values are not configured can learn timer values from the active or standby router. The timers configured on an active router always override any other timer settings.
- All routers in a Hot Standby group should use the same timer values. Normally, the *holdtime* is greater than or equal to 3 times the *hellotime*.

Beginning in privileged EXEC mode, use one or more of these steps to configure HSRP authentication and timers on an interface:

### Procedure

	Command or Action	Purpose
Step 1	<code>configure terminal</code> <b>Example:</b> Switch # <code>configure terminal</code>	Enters global configuration mode.
Step 2	<code>interface interface-id</code> <b>Example:</b> Switch(config) # <code>interface gigabitethernet1/0/1</code>	Enters interface configuration mode, and enter the HSRP interface on which you want to set priority.
Step 3	<code>standby [group-number] authentication string</code> <b>Example:</b> Switch(config-if) # <code>standby 1 authentication word</code>	(Optional) <b>authentication string</b> —Enter a string to be carried in all HSRP messages. The authentication string can be up to eight characters in length; the default string is <b>cisco</b> .  (Optional) <b>group-number</b> —The group number to which the command applies.
Step 4	<code>standby [group-number] timers hellotime holdtime</code> <b>Example:</b> Switch(config-if) # <code>standby 1 timers 5 15</code>	(Optional) Configure the time between hello packets and the time before other routers declare the active router to be down.  <ul style="list-style-type: none"> <li>• <b>group-number</b>—The group number to which the command applies.</li> <li>• <b>hellotime</b> —Set to cause the local router to postpone taking over the active role for</li> </ul>

	Command or Action	Purpose
		<p>the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over).</p> <ul style="list-style-type: none"> <li>• <i>holdtime</i>—Set to cause the local router to postpone taking over the active role after a reload for the number of seconds shown. The range is 0 to 3600 seconds (1 hour); the default is 0 (no delay before taking over after a reload).</li> </ul>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Switch(config-if) # end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b>	Verifies the configuration of the standby groups.
<b>Step 7</b>	<b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Enabling HSRP Support for ICMP Redirect Messages

ICMP redirect messages are automatically enabled on interfaces configured with HSRP. ICMP is a network layer Internet protocol that provides message packets to report errors and other information relevant to IP processing. ICMP provides diagnostic functions, such as sending and directing error packets to the host. This feature filters outgoing ICMP redirect messages through HSRP, in which the next hop IP address might be changed to an HSRP virtual IP address. For more information, see the Cisco IOS IP Configuration Guide, Release 12.4.

## Configuring HSRP Groups and Clustering

When a device is participating in an HSRP standby routing and clustering is enabled, you can use the same standby group for command switch redundancy and HSRP redundancy. Use the **cluster standby-group HSRP-group-name [routing-redundancy]** global configuration command to enable the same HSRP standby group to be used for command switch and routing redundancy. If you create a cluster with the same HSRP standby group name without entering the **routing-redundancy** keyword, HSRP standby routing is disabled for the group.

## Verifying HSRP

### Verifying HSRP Configurations

From privileged EXEC mode, use this command to display HSRP settings:

```
show standby [interface-id [group]] [brief] [detail]
```

You can display HSRP information for the whole switch, for a specific interface, for an HSRP group, or for an HSRP group on an interface. You can also specify whether to display a concise overview of HSRP



information or detailed HSRP information. The default display is **detail**. If there are a large number of HSRP groups, using the **show standby** command without qualifiers can result in an unwieldy display.

### Example

```
Switch #show standby
VLAN1 - Group 1
Local state is Standby, priority 105, may preempt
Hellotime 3 holdtime 10
Next hello sent in 00:00:02.182
Hot standby IP address is 172.20.128.3 configured
Active router is 172.20.128.1 expires in 00:00:09
Standby router is local
Standby virtual mac address is 0000.0c07.ac01
Name is bbb

VLAN1 - Group 100
Local state is Standby, priority 105, may preempt
Hellotime 3 holdtime 10
Next hello sent in 00:00:02.262
Hot standby IP address is 172.20.138.51 configured
Active router is 172.20.128.1 expires in 00:00:09
Active router is local
Standby router is unknown expired
Standby virtual mac address is 0000.0c07.ac64
Name is test
```

## Configuration Examples for Configuring HSRP

### Enabling HSRP: Example

This example shows how to activate HSRP for group 1 on an interface. The IP address used by the hot standby group is learned by using HSRP.



**Note** This procedure is the minimum number of steps required to enable HSRP. Other configurations are optional.

```
Switch # configure terminal
Switch(config) # interface gigabitethernet1/0/1
Switch(config-if) # no switchport
Switch(config-if) # standby 1 ip
Switch(config-if) # end
Switch # show standby
```

### Configuring HSRP Priority: Example

This example activates a port, sets an IP address and a priority of 120 (higher than the default value), and waits for 300 seconds (5 minutes) before attempting to become the active router:

```
Switch # configure terminal
Switch(config) # interface gigabitethernet1/0/1
Switch(config-if) # no switchport
Switch(config-if) # standby ip 172.20.128.3
Switch(config-if) # standby priority 120 preempt delay 300
```

```
Switch(config-if)# end
Switch # show standby
```

## Configuring MHSRP: Example

This example shows how to enable the MHSRP configuration shown in the figure *MHSRP Load Sharing*

### Router A Configuration

```
Switch # configure terminal
Switch(config) # interface gigabitethernet1/0/1
Switch(config-if) # no switchport
Switch(config-if) # ip address 10.0.0.1 255.255.255.0
Switch(config-if) # standby ip 10.0.0.3
Switch(config-if) # standby 1 priority 110
Switch(config-if) # standby 1 preempt
Switch(config-if) # standby 2 ip 10.0.0.4
Switch(config-if) # standby 2 preempt
Switch(config-if) # end
```

### Router B Configuration

```
Switch # configure terminal
Switch(config) # interface gigabitethernet1/0/1
Switch(config-if) # no switchport
Switch(config-if) # ip address 10.0.0.2 255.255.255.0
Switch(config-if) # standby ip 10.0.0.3
Switch(config-if) # standby 1 preempt
Switch(config-if) # standby 2 ip 10.0.0.4
Switch(config-if) # standby 1 priority 110
Switch(config-if) # standby 2 preempt
Switch(config-if) # end
```

## Configuring HSRP Authentication and Timer: Example

This example shows how to configure word as the authentication string required to allow Hot Standby routers in group 1 to interoperate:

```
Switch # configure terminal
Switch(config) # interface gigabitethernet1/0/1
Switch(config-if) # no switchport
Switch(config-if) # standby 1 authentication word
Switch(config-if) # end
```

This example shows how to set the timers on standby group 1 with the time between hello packets at 5 seconds and the time after which a router is considered down to be 15 seconds:

```
Switch # configure terminal
Switch(config) # interface gigabitethernet1/0/1
Switch(config-if) # no switchport
Switch(config-if) # standby 1 ip
Switch(config-if) # standby 1 timers 5 15
Switch(config-if) # end
```

## Configuring HSRP Groups and Clustering: Example

This example shows how to bind standby group `my_hsrp` to the cluster and enable the same HSRP group to be used for command switch redundancy and router redundancy. The command can only be executed on the cluster command switch. If the standby group name or number does not exist, or if the switch is a cluster member switch, an error message appears.

```
Switch # configure terminal
Switch(config) # cluster standby-group my_hsrp routing-redundancy
Switch(config-if) # end
```

## Additional References for Configuring HSRP

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>

### Standards and RFCs

Standard/RFC	Title
<i>RFC 2281</i>	Cisco Hot Standby Router Protocol

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for Configuring HSRP

*Table 28: Feature Information for Configuring HSRP*

<b>Release</b>	<b>Feature Information</b>
Cisco IOS XE 3.3SE	This feature was introduced.



## CHAPTER 24

# Configuring NHRP

The Next Hop Resolution Protocol (NHRP) is an Address Resolution Protocol (ARP)-like protocol that dynamically maps a nonbroadcast multiaccess (NBMA) network, instead of manually configuring all the tunnel end points. With NHRP, systems attached to an NBMA network can dynamically learn the NBMA (physical) address of the other systems that are part of that network, allowing these systems to directly communicate. This protocol provides an ARP-like solution which allows stations' data-link addresses to be dynamically determined.

NHRP is a client and server protocol where the hub is the Next Hop Server (NHS) and the spokes are the Next Hop Clients (NHCs). The hub maintains an NHRP database of the public interface addresses of each spoke. Each spoke registers its non-NBMA (real) address when it boots and queries the NHRP database for addresses of the destination spokes to build direct tunnels.

This module explains how to configure NHRP with generic routing encapsulation (GRE). In Cisco IOS XE Denali 16.3.1, the NHRP supports only spoke configurations.

- [Information About Configuring NHRP, on page 383](#)
- [How to Configure NHRP, on page 384](#)
- [Configuration Examples for NHRP, on page 387](#)
- [Additional References for Configuring NHRP, on page 390](#)
- [Feature Information for Configuring NHRP, on page 390](#)

## Information About Configuring NHRP

### NHRP and NBMA Network Interaction

Most WAN networks are a collection of point-to-point links. Virtual tunnel networks (for example Generic Routing Encapsulation [GRE] tunnels) are also a collection of point-to-point links. To effectively scale the connectivity of these point-to-point links, they are usually grouped into a single or multilayer hub-and-spoke network. Multipoint interfaces (for example, GRE tunnel interfaces) can be used to reduce the configuration on a hub router in such a network. This resulting network is a NBMA network.

Because there are multiple tunnel endpoints that are reachable through a single multipoint interface, there needs to be a mapping from the logical tunnel endpoint IP address to the physical tunnel endpoint IP address, to forward packets out of the tunnel interfaces over this NBMA network. This mapping could be statically configured, but it is preferable if the mapping can be discovered or learned dynamically.

NHRP is an ARP-like protocol that alleviates these NBMA network problems. With NHRP, systems attached to an NBMA network dynamically learn the NBMA address of other systems that are part of the network, allowing these systems to directly communicate without requiring traffic to use an intermediate hop.

Routers, access servers, and hosts can use NHRP to discover the addresses of other routers and hosts connected to an NBMA network. Partially-meshed NBMA networks typically have multiple logical networks behind the NBMA network. In such configurations, packets traversing the NBMA network might have to make several hops over the NBMA network before arriving at the exit router (the router nearest the destination network).

NHRP Registration helps support these NBMA networks:

- **NHRP Registration**—NHRP allows Next Hop Clients (NHCs) to dynamically register with Next Hop Servers (NHSs). This registration function allows the NHCs to join the NBMA network without configuration changes on the NHSs, especially in cases where the NHC has a dynamic physical IP address or is behind a Network Address Translation (NAT) router that dynamically changes the physical IP address. In these cases, it would be impossible to preconfigure the logical (VPN IP address) to physical (NBMA IP) mapping for the NHC on the NHS.

## Dynamically Built Hub-and-Spoke Networks

With NHRP, the NBMA network is initially laid out as a hub-and-spoke network that can have multiple hierarchical layers of NHCs as spokes and NHSs as hubs. The NHCs are configured with static mapping information to reach their NHSs and will connect to their NHS and send an NHRP registration to the NHS. This configuration allows the NHS to dynamically learn the mapping information for the spoke, reducing the configuration needed on the hub and allowing the spoke to obtain a dynamic NBMA (physical) IP address.

# How to Configure NHRP

## Enabling NHRP on an Interface

Perform this task to enable NHRP for an interface on a switch. In general, all NHRP stations within a logical NBMA network should be configured with the same network identifier.

The NHRP network ID is used to define the NHRP domain for an NHRP interface and differentiate between multiple NHRP domains or networks, when two or more NHRP domains (GRE tunnel interfaces) are available on the same NHRP node (switch). The NHRP network ID helps keep two NHRP networks (clouds) separate when both are configured on the same switch.

The NHRP network ID is a local-only parameter. It is significant only to the local switch and is not transmitted in NHRP packets to other NHRP nodes. For this reason the actual value of the NHRP network ID configured on a switch need not match the same NHRP network ID on another switch where both of these switches are in the same NHRP domain. As NHRP packets arrive on a GRE interface, they are assigned to the local NHRP domain in the NHRP network ID that is configured on that interface.

We recommend that the same NHRP network ID be used on the GRE interfaces on all switches that are in the same NHRP network. It is then easier to track which GRE interfaces are members of which NHRP network.

NHRP domains (network IDs) can be unique on each GRE tunnel interface on a switch. NHRP domains can span across GRE tunnel interfaces on a route. In this case the effect of using the same NHRP network ID on the GRE tunnel interfaces is to merge the two GRE interfaces into a single NHRP network.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Switch> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Switch# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>type number</i></b> <b>Example:</b>  Switch(config)# interface tunnel 100	Configures an interface and enters interface configuration mode.
<b>Step 4</b>	<b>ip address <i>ip-address network-mask</i></b> <b>Example:</b>  Switch(config-if)# ip address 10.0.0.1 255.255.255.0	Enables IP and gives the interface an IP address.
<b>Step 5</b>	<b>ip nhrp network-id <i>number</i></b> <b>Example:</b>  Switch(config-if)# ip nhrp network-id 1	Enables NHRP on the interface.
<b>Step 6</b>	<b>end</b> <b>Example:</b>  Switch(config)# end	Exits interface configuration mode and returns to privileged EXEC mode.

## Configuring a GRE Tunnel for Multipoint Operation

Perform this task to configure a GRE tunnel for multipoint (NMBA) operation.

A tunnel network of multipoint tunnel interfaces can be considered of as an NBMA network. When multiple GRE tunnels are configured on the same switch, they must either have unique tunnel ID keys or unique tunnel source addresses.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Switch> enable	Enables privileged EXEC mode.  • Enter your password if prompted.

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Switch# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>type number</i></b> <b>Example:</b> <pre>Switch(config)# interface tunnel 100</pre>	Configures an interface and enters interface configuration mode.
<b>Step 4</b>	<b>ip address <i>ip-address</i></b> <b>Example:</b> <pre>Switch(config-if)# ip address 172.16.1.1 255.255.255.0</pre>	Configures an IP address for the interface.
<b>Step 5</b>	<b>ip mtu <i>bytes</i></b> <b>Example:</b> <pre>Switch(config-if)# ip mtu 1400</pre>	Sets the maximum transmission unit (MTU) size of IP packets sent on an interface.
<b>Step 6</b>	<b>ip pim sparse-dense-mode</b> <b>Example:</b> <pre>Switch(config-if)# ip pim sparse-dense-mode</pre>	Enables Protocol Independent Multicast (PIM) on an interface and treats the interface in either sparse mode or dense mode of operation, depending on which mode the multicast group operates in.
<b>Step 7</b>	<b>ip nhrp map <i>ip-address nbma-address</i></b> <b>Example:</b> <pre>Switch(config-if)# ip nhrp map 172.16.1.2 10.10.10.2</pre>	Statically configures the IP-to-nonbroadcast multiaccess (NBMA) address mapping of IP destinations connected to an NBMA network. <ul style="list-style-type: none"> <li>• <i>ip-address</i>—IP address of the destinations reachable through the NBMA network. This address is mapped to the NBMA address.</li> <li>• <i>nbma-address</i>—NBMA address that is directly reachable through the NBMA network. The address format varies depending on the medium used. For example, ATM has a Network Service Access Point (NSAP) address, Ethernet has a MAC address, and Switched Multimegabit Data Service (SMDS) has an E.164 address. This address is mapped to the IP address.</li> </ul>
<b>Step 8</b>	<b>ip nhrp map multicast <i>nbma-address</i></b> <b>Example:</b>	Configures nonbroadcast multiaccess (NBMA) addresses used as destinations for broadcast



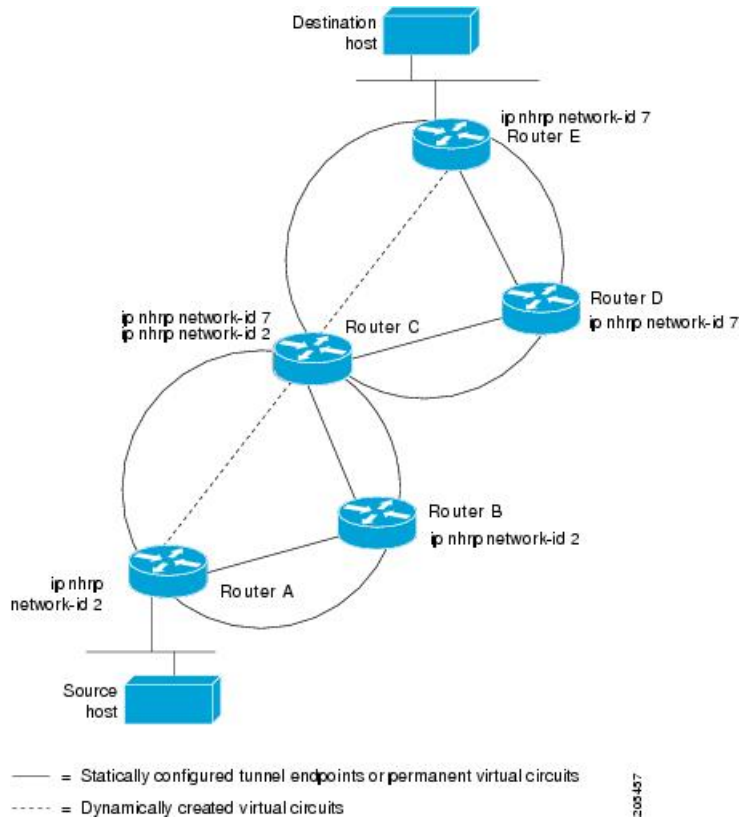
	Command or Action	Purpose
	Switch(config-if)# ip nhrp map multicast 10.10.10.2	or multicast packets to be sent over a tunnel network.
<b>Step 9</b>	<b>ip nhrp network-id <i>number</i></b> <b>Example:</b>  Switch(config-if)# ip nhrp network-id 1	Enable the Next Hop Resolution Protocol (NHRP) on an interface. <ul style="list-style-type: none"> <li><i>number</i>—Globally unique, 32-bit network ID from a nonbroadcast multiaccess (NBMA) network. The range is from 1 to 4294967295.</li> </ul>
<b>Step 10</b>	<b>ip nhrp nhs <i>nhs-address</i></b> <b>Example:</b>  Switch(config-if)# ip nhrp nhs 172.16.1.2	Specifies the address of one or more NHRP servers. <ul style="list-style-type: none"> <li><i>nhs-address</i>—Address of the next-hop server being specified.</li> </ul>
<b>Step 11</b>	<b>tunnel source vlan <i>interface-number</i></b> <b>Example:</b>  Switch(config-if)# tunnel source vlan 1	Sets the source address for a tunnel interface
<b>Step 12</b>	<b>tunnel destination <i>ip-address</i></b> <b>Example:</b>  Switch(config-if)# tunnel destination 10.10.10.2	Sets the destination address for a tunnel interface.
<b>Step 13</b>	<b>end</b> <b>Example:</b>  Switch(config-if)# end	Exits interface configuration mode and returns to privileged EXEC mode.

## Configuration Examples for NHRP

### Physical Network Designs for Logical NBMA Examples

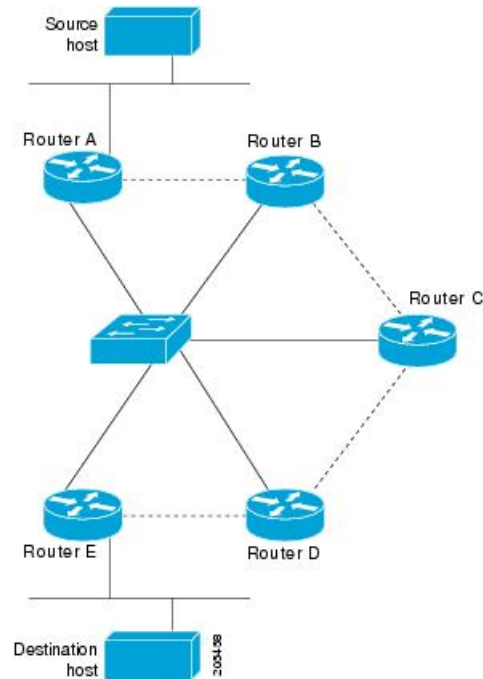
A logical NBMA network is considered the group of interfaces and hosts participating in NHRP and having the same network identifier. The figure below illustrates two logical NBMA networks (shown as circles) configured over a single physical NBMA network. Router A can communicate with routers B and C because they share the same network identifier (2). Router C can also communicate with routers D and E because they share network identifier 7. After address resolution is complete, router A can send IP packets to router C in one hop, and router C can send them to router E in one hop, as shown by the dotted lines.

Figure 18: Two Logical NBMA Networks over One Physical NBMA Network



The physical configuration of the five routers in the figure above might actually be that shown in the figure below. The source host is connected to router A and the destination host is connected to router E. The same switch serves all five routers, making one physical NBMA network.

Figure 19: Physical Configuration of a Sample NBMA Network



Refer again to the first figure above. Initially, before NHRP has resolved any NBMA addresses, IP packets from the source host to the destination host travel through all five routers connected to the switch before reaching the destination. When router A first forwards the IP packet toward the destination host, router A also generates an NHRP request for the IP address of the destination host. The request is forwarded to router C, whereupon a reply is generated. Router C replies because it is the egress router between the two logical NBMA networks.

Similarly, router C generates an NHRP request of its own, to which router E replies. In this example, subsequent IP traffic between the source and the destination still requires two hops to traverse the NBMA network, because the IP traffic must be forwarded between the two logical NBMA networks. Only one hop would be required if the NBMA network were not logically divided.

## Example: GRE Tunnel for Multipoint Operation

With multipoint tunnels, a single tunnel interface may be connected to multiple neighboring switches. Unlike point-to-point tunnels, a tunnel destination need not be configured. In fact, if configured, the tunnel destination must correspond to an IP multicast address.

In the following example, switches A and B share an Ethernet segment. Minimal connectivity over the multipoint tunnel network is configured, thus creating a network that can be treated as a partially meshed NBMA network. Due to the static NHRP map entries, switch A knows how to reach switch B and vice versa.

The following example shows how to configure a GRE multipoint tunnel:

### Switch A Configuration

```
Switch(config)# interface tunnel 100 !Tunnel interface configured for PIM traffic
Switch(config-if)# no ip redirects
Switch(config-if)# ip address 192.168.24.1 255.255.255.252
```

```
Switch(config-if)# ip mtu 1400
Switch(config-if)# ip pim sparse-dense-mode
Switch(config-if)# ip nhrp map 192.168.24.3 172.16.0.1 !NHRP may optionally be configured
to dynamically discover tunnel end points.
Switch(config-if)# ip nhrp map multicast 172.16.0.1
Switch(config-if)# ip nhrp network-id 1
Switch(config-if)# ip nhrp nhs 192.168.24.3
Switch(config-if)# tunnel source vlan 1
Switch(config-if)# tunnel destination 172.16.0.1
Switch(config-if)# end
```

### Switch B Configuration

```
Switch(config)# interface tunnel 100
Switch(config-if)# no ip redirects
Switch(config-if)# ip address 192.168.24.2 255.255.255.252
Switch(config-if)# ip mtu 1400
Switch(config-if)# ip pim sparse-dense-mode
Switch(config-if)# ip nhrp map 192.168.24.4 10.10.0.3
Switch(config-if)# ip nhrp map multicast 10.10.10.3
Switch(config-if)# ip nhrp network-id 1
Switch(config-if)# ip nhrp nhs 192.168.24.4
Switch(config-if)# tunnel source vlan 1
Switch(config-if)# tunnel destination 10.10.10.3
Switch(config-if)# end
```

## Additional References for Configuring NHRP

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>

### RFCs

RFC	Title
<i>RFC 2332</i>	<i>NBMA Next Hop Resolution Protocol (NHRP)</i>

## Feature Information for Configuring NHRP

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

Table 29: Feature Information for Configuring NHRP

Feature Name	Releases	Feature Information
Next Hop Resolution Protocol	Cisco IOS XE Polaris 16.3.1	The Next Hop Resolution Protocol (NHRP) is an Address Resolution Protocol (ARP)-like protocol that dynamically maps a nonbroadcast multiaccess (NBMA) network instead of manually configuring all the tunnel end points. With NHRP, systems attached to an NBMA network can dynamically learn the NBMA (physical) address of the other systems that are part of that network, allowing these systems to directly communicate.
		<p>This feature was implemented on the following platforms:</p> <ul style="list-style-type: none"> <li>• Cisco Catalyst 3650 Series Switches</li> <li>• Cisco Catalyst 3850 Series Switches</li> <li>• Cisco Catalyst 9300 Series Switches</li> <li>• Cisco Catalyst 9500 Series Switches</li> </ul>





## CHAPTER 25

# VRRPv3 Protocol Support

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- [VRRPv3 Protocol Support, on page 393](#)

## VRRPv3 Protocol Support

Virtual Router Redundancy Protocol (VRRP) enables a group of devices to form a single virtual device to provide redundancy. The LAN clients can then be configured with the virtual device as their default gateway. The virtual device, representing a group of devices, is also known as a VRRP group. The VRRP version 3 (v3) Protocol Support feature provides the capability to support IPv4 and IPv6 addresses while VRRP version 2 (v2) only supports IPv4 addresses. This module explains concepts related to VRRPv3 and describes how to create and customize a VRRP group in a network. Benefits of using VRRPv3 Protocol Support include the following:

- Interoperability in multi-vendor environments.
- VRRPv3 supports usage of IPv4 and IPv6 addresses while VRRPv2 only supports IPv4 addresses
- Improved scalability through the use of VRRS Pathways.



---

**Note** In this module, VRRP and VRRPv3 are used interchangeably.

---

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Restrictions for VRRPv3 Protocol Support

- VRRPv3 is not intended as a replacement for existing dynamic protocols. VRRPv3 is designed for use over multi-access, multicast, or broadcast capable Ethernet LANs.
- VRRPv3 is supported on Ethernet, Fast Ethernet, Bridge Group Virtual Interface (BVI), and Gigabit Ethernet interfaces, and on Multiprotocol Label Switching (MPLS) Virtual Private Networks (VPNs), VRF-aware MPLS VPNs and VLANs.
- Because of the forwarding delay that is associated with the initialization of a BVI interface, you must not configure the VRRPv3 advertise timer to a value lesser than the forwarding delay on the BVI interface. If you configure the VRRPv3 advertise timer to a value equal to or greater than the forwarding delay on the BVI interface, the setting prevents a VRRP device on a recently initialized BVI interface from unconditionally taking over the master role. Use the **bridge forward-time** command to set the forwarding delay on the BVI interface. Use the **vrrp timers advertise** command to set the VRRP advertisement timer.
- VRRPv3 does not support Stateful Switchover (SSO).
- Full network redundancy can only be achieved if VRRP operates over the same network path as the VRRS Pathway redundant interfaces. For full redundancy, the following restrictions apply:
  - VRRS pathways should not share a different physical interface as the parent VRRP group or be configured on a sub-interface having a different physical interface as the parent VRRP group.
  - VRRS pathways should not be configured on Switch Virtual Interface (SVI) interfaces as long as the associated VLAN does not share the same trunk as the VLAN on which the parent VRRP group is configured.

## Information About VRRPv3 Protocol Support

### VRRPv3 Benefits

#### Support for IPv4 and IPv6

VRRPv3 supports IPv4 and IPv6 address families while VRRPv2 only supports IPv4 addresses.



#### Note

When VRRPv3 is in use, VRRPv2 is unavailable. For VRRPv3 to be configurable, the **hrrp version vrrp v3** command must be used in global configuration mode

#### Redundancy

VRRP enables you to configure multiple devices as the default gateway device, which reduces the possibility of a single point of failure in a network.

#### Load Sharing

You can configure VRRP in such a way that traffic to and from LAN clients can be shared by multiple devices, thereby sharing the traffic load more equitably between available devices.



### Multiple Virtual Devices

VRRP supports up to 255 virtual devices (VRRP groups) on a device physical interface, subject to restrictions in scaling. Multiple virtual device support enables you to implement redundancy and load sharing in your LAN topology. In scaled environments, VRRS Pathways should be used in combination with VRRP control groups.

### Multiple IP Addresses

The virtual device can manage multiple IP addresses, including secondary IP addresses. Therefore, if you have multiple subnets configured on an Ethernet interface, you can configure VRRP on each subnet.



---

**Note** To utilize secondary IP addresses in a VRRP group, a primary address must be configured on the same group.

---

### Preemption

The redundancy scheme of VRRP enables you to preempt a virtual device backup that has taken over for a failing virtual device master with a higher priority virtual device backup that has become available.



---

**Note** Preemption of a lower priority master device is enabled with an optional delay.

---

### Advertisement Protocol

VRRP uses a dedicated Internet Assigned Numbers Authority (IANA) standard multicast address for VRRP advertisements. For IPv4, the multicast address is 224.0.0.18. For IPv6, the multicast address is FF02:0:0:0:0:0:0:12. This addressing scheme minimizes the number of devices that must service the multicasts and allows test equipment to accurately identify VRRP packets on a segment. The IANA has assigned VRRP the IP protocol number 112.

## VRRP Device Priority and Preemption

An important aspect of the VRRP redundancy scheme is VRRP device priority. Priority determines the role that each VRRP device plays and what happens if the virtual device master fails.

If a VRRP device owns the IP address of the virtual device and the IP address of the physical interface, this device will function as a virtual device master.

Priority also determines if a VRRP device functions as a virtual device backup and the order of ascendancy to becoming a virtual device master if the virtual device master fails. You can configure the priority of each virtual device backup with a value of 1 through 254 using the **priority** command (use the **vrrp address-family** command to enter the VRRP configuration mode and access the **priority** option).

For example, if device A, the virtual device master in a LAN topology, fails, an election process takes place to determine if virtual device backups B or C should take over. If devices B and C are configured with the priorities of 101 and 100, respectively, device B is elected to become virtual device master because it has the higher priority. If devices B and C are both configured with the priority of 100, the virtual device backup with the higher IP address is elected to become the virtual device master.

By default, a preemptive scheme is enabled whereby a higher priority virtual device backup that becomes available takes over from the virtual device backup that was elected to become virtual device master. You

can disable this preemptive scheme using the **no preempt** command (use the **vrrp address-family** command to enter the VRRP configuration mode, and enter the **no preempt** command). If preemption is disabled, the virtual device backup that is elected to become virtual device master remains the master until the original virtual device master recovers and becomes master again.



---

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---

## VRRP Advertisements

The virtual device master sends VRRP advertisements to other VRRP devices in the same group. The advertisements communicate the priority and state of the virtual device master. The VRRP advertisements are encapsulated into either IPv4 or IPv6 packets (based on the VRRP group configuration) and sent to the appropriate multicast address assigned to the VRRP group. For IPv4, the multicast address is 224.0.0.18. For IPv6, the multicast address is FF02:0:0:0:0:0:12. The advertisements are sent every second by default and the interval is configurable.

Cisco devices allow you to configure millisecond timers, which is a change from VRRPv2. You need to manually configure the millisecond timer values on both the primary and the backup devices. The master advertisement value displayed in the **show vrrp** command output on the backup devices is always 1 second because the packets on the backup devices do not accept millisecond values.

You must use millisecond timers where absolutely necessary and with careful consideration and testing. Millisecond values work only under favorable circumstances. The use of the millisecond timer values is compatible with third party vendors, as long as they also support VRRPv3. You can specify a timer value between 100 milliseconds and 40000 milliseconds.

## Information About VRRPv3 Protocol Support

### VRRPv3 Benefits

#### Support for IPv4 and IPv6

VRRPv3 supports IPv4 and IPv6 address families while VRRPv2 only supports IPv4 addresses.



---

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---

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---

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You must use millisecond timers where absolutely necessary and with careful consideration and testing. Millisecond values work only under favorable circumstances. The use of the millisecond timer values is compatible with third party vendors, as long as they also support VRRPv3. You can specify a timer value between 100 milliseconds and 40000 milliseconds.

## How to Configure VRRPv3 Protocol Support

### Enabling and Verifying GLBP

Perform this task to enable GLBP on an interface and verify its configuration and operation. GLBP is designed to be easy to configure. Each gateway in a GLBP group must be configured with the same group number, and at least one gateway in the GLBP group must be configured with the virtual IP address to be used by the group. All other required parameters can be learned.

#### Before you begin

If VLANs are in use on an interface, the GLBP group number must be different for each VLAN.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>type number</i></b> <b>Example:</b>  Device(config)# interface GigabitEthernet 1/0/1	Specifies an interface type and number, and enters interface configuration mode.
<b>Step 4</b>	<b>ip address <i>ip-address mask</i> [secondary]</b> <b>Example:</b>  Device(config-if)# ip address 10.21.8.32 255.255.255.0	Specifies a primary or secondary IP address for an interface.
<b>Step 5</b>	<b>glbp group ip [<i>ip-address</i> [secondary]]</b> <b>Example:</b>  Device(config-if)# glbp 10 ip 10.21.8.10	Enables GLBP on an interface and identifies the primary IP address of the virtual gateway. <ul style="list-style-type: none"> <li>• After you identify a primary IP address, you can use the <b>glbp group ip</b> command again with the <b>secondary</b> keyword to indicate additional IP addresses supported by this group.</li> </ul>
<b>Step 6</b>	<b>end</b> <b>Example:</b>  Device(config-if)# end	Exits interface configuration mode, and returns the device to privileged EXEC mode.
<b>Step 7</b>	<b>show glbp [<i>interface-type interface-number</i>] [<i>group</i>] [<i>state</i>] [<i>brief</i>]</b> <b>Example:</b>  Device(config)# show glbp GigabitEthernet 1/0/1 10	(Optional) Displays information about GLBP groups on a device. <ul style="list-style-type: none"> <li>• Use the optional <b>brief</b> keyword to display a single line of information about each virtual gateway or virtual forwarder.</li> </ul>

### Example

In the following example, sample output is displayed about the status of the GLBP group, named 10, on the device:

```
Device# show glbp GigabitEthernet 1/0/1 10
GigabitEthernet1/0/1 - Group 10
  State is Active
    1 state change, last state change 00:04:52
  Virtual IP address is 10.21.8.10
  Hello time 3 sec, hold time 10 sec
```

```

Next hello sent in 0.608 secs
Redirect time 600 sec, forwarder time-out 14400 sec
Preemption disabled
Active is local
Standby is unknown
Priority 100 (default)
Weighting 100 (default 100), thresholds: lower 1, upper 100
Load balancing: round-robin
Group members:
  ac7e.8a35.6364 (10.21.8.32) local
There is 1 forwarder (1 active)
Forwarder 1
  State is Active
    1 state change, last state change 00:04:41
  MAC address is 0007.b400.0a01 (default)
  Owner ID is ac7e.8a35.6364
  Redirection enabled
  Preemption enabled, min delay 30 sec
  Active is local, weighting 100

```

## Creating and Customizing a VRRP Group

To create a VRRP group, perform the following task. Steps 6 to 14 denote customizing options for the group, and they are optional:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>fhrp version vrrp v3</b> <b>Example:</b> Device(config)# fhrp version vrrp v3	Enables the ability to configure VRRPv3 and VRRS. <p><b>Note</b> When VRRPv3 is in use, VRRPv2 is unavailable.</p> <p>The command <b>fhrp version vrrp v2</b> is not supported though it is configurable.</p>
<b>Step 4</b>	<b>interface type number</b> <b>Example:</b> Device(config)# interface GigabitEthernet 0/0/0	Enters interface configuration mode.

	Command or Action	Purpose
<b>Step 5</b>	<b>vrrp</b> <i>group-id</i> <b>address-family</b> { <b>ipv4</b>   <b>ipv6</b> } <b>Example:</b> <pre>Device(config-if)# vrrp 3 address-family   ipv4</pre>	Creates a VRRP group and enters VRRP configuration mode.
<b>Step 6</b>	<b>address</b> <i>ip-address</i> [ <b>primary</b>   <b>secondary</b> ] <b>Example:</b> <pre>Device(config-if-vrrp)# address   100.0.1.10 primary</pre>	Specifies a primary or secondary address for the VRRP group. <b>Note</b> VRRPv3 for IPv6 requires that a primary virtual link-local IPv6 address is configured to allow the group to operate. After the primary link-local IPv6 address is established on the group, you can add the secondary global addresses.
<b>Step 7</b>	<b>description</b> <i>group-description</i> <b>Example:</b> <pre>Device(config-if-vrrp)# description   group 3</pre>	(Optional) Specifies a description for the VRRP group.
<b>Step 8</b>	<b>match-address</b> <b>Example:</b> <pre>Device(config-if-vrrp)# match-address</pre>	(Optional) Matches secondary address in the advertisement packet against the configured address. <ul style="list-style-type: none"> <li>• Secondary address matching is enabled by default.</li> </ul>
<b>Step 9</b>	<b>preempt delay minimum</b> <i>seconds</i> <b>Example:</b> <pre>Device(config-if-vrrp)# preempt delay   minimum 30</pre>	(Optional) Enables preemption of lower priority master device with an optional delay. <ul style="list-style-type: none"> <li>• Preemption is enabled by default.</li> </ul>
<b>Step 10</b>	<b>priority</b> <i>priority-level</i> <b>Example:</b> <pre>Device(config-if-vrrp)# priority 3</pre>	(Optional) Specifies the priority value of the VRRP group. <ul style="list-style-type: none"> <li>• The priority of a VRRP group is 100 by default.</li> </ul>
<b>Step 11</b>	<b>timers advertise</b> <i>interval</i> <b>Example:</b> <pre>Device(config-if-vrrp)# timers advertise   1000</pre>	(Optional) Sets the advertisement timer in milliseconds. <ul style="list-style-type: none"> <li>• The advertisement timer is set to 1000 milliseconds by default.</li> </ul>
<b>Step 12</b>	<b>vrrpv2</b> <b>Example:</b>	(Optional) Enables support for VRRPv2 configured devices in compatibility mode.

	Command or Action	Purpose
	<code>Device(config-if-vrrp)# vrrpv2</code>	<ul style="list-style-type: none"> <li>VRRPv2 is not supported.</li> </ul>
<b>Step 13</b>	<b>vrrs leader <i>vrrs-leader-name</i></b> <b>Example:</b> <code>Device(config-if-vrrp)# vrrs leader leader-1</code>	(Optional) Specifies a leader's name to be registered with VRRS and to be used by followers. <ul style="list-style-type: none"> <li>A registered VRRS name is unavailable by default.</li> </ul>
<b>Step 14</b>	<b>shutdown</b> <b>Example:</b> <code>Device(config-if-vrrp)# shutdown</code>	(Optional) Disables VRRP configuration for the VRRP group. <ul style="list-style-type: none"> <li>VRRP configuration is enabled for a VRRP group by default.</li> </ul>
<b>Step 15</b>	<b>end</b> <b>Example:</b> <code>Device(config)# end</code>	Returns to privileged EXEC mode.

## Configuring the Delay Period Before FHRP Client Initialization

To configure the delay period before the initialization of all FHRP clients on an interface, perform the following task:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <code>Device&gt; enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <code>Device# configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>fhrp version vrrp v3</b> <b>Example:</b> <code>Device(config)# fhrp version vrrp v3</code>	Enables the ability to configure VRRPv3 and VRRS. <b>Note</b> When VRRPv3 is in use, VRRPv2 is unavailable.
<b>Step 4</b>	<b>interface <i>type number</i></b> <b>Example:</b>	Enters interface configuration mode.



	Command or Action	Purpose
	Device(config)# interface GigabitEthernet 0/0/0	
<b>Step 5</b>	<b>fhrp delay</b> {[minimum] [reload] seconds} <b>Example:</b> Device(config-if)# fhrp delay minimum 5	Specifies the delay period for the initialization of FHRP clients after an interface comes up. <ul style="list-style-type: none"> <li>• The range is 0-3600 seconds.</li> </ul>
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# end	Returns to privileged EXEC mode.

## Configuration Examples for VRRPv3 Protocol Support

### Example: Enabling VRRPv3 on a Device

The following example shows how to enable VRRPv3 on a device:

```
Device> enable
Device# configure terminal
Device(config)# fhrp version vrrp v3
Device(config-if-vrrp)# end
```

### Example: Creating and Customizing a VRRP Group

The following example shows how to create and customize a VRRP group:

```
Device> enable
Device# configure terminal
Device(config)# fhrp version vrrp v3
Device(config)# interface GigabitEthernet 1/0/1
Device(config-if)# vrrp 3 address-family ipv4
Device(config-if-vrrp)# address 100.0.1.10 primary
Device(config-if-vrrp)# description group 3
Device(config-if-vrrp)# match-address
Device(config-if-vrrp)# preempt delay minimum 30
Device(config-if-vrrp)# end
```



**Note** In the above example, the `fhrp version vrrp v3` command is used in the global configuration mode.

### Example: Configuring the Delay Period Before FHRP Client Initialization

The following example shows how to configure the delay period before FHRP client initialization :

```

Device> enable
Device# configure terminal
Device(config)# fhrp version vrrp v3
Device(config)# interface GigabitEthernet 1/0/1
Device(config-if)# fhrp delay minimum 5
Device(config-if-vrrp)# end

```




---

**Note** In the above example, a five-second delay period is specified for the initialization of FHRP clients after the interface comes up. You can specify a delay period between 0 and 3600 seconds.

---

## Example: VRRP Status, Configuration, and Statistics Details

The following is a sample output of the status, configuration and statistics details for a VRRP group:

```

Device> enable
Device# show vrrp detail

GigabitEthernet1/0/1 - Group 3 - Address-Family IPv4
  Description is "group 3"
  State is MASTER
  State duration 53.901 secs
  Virtual IP address is 100.0.1.10
  Virtual MAC address is 0000.5E00.0103
  Advertisement interval is 1000 msec
  Preemption enabled, delay min 30 secs (0 msec remaining)
  Priority is 100
  Master Router is 10.21.0.1 (local), priority is 100
  Master Advertisement interval is 1000 msec (expires in 832 msec)
  Master Down interval is unknown
  VRRPv3 Advertisements: sent 61 (errors 0) - rcvd 0
  VRRPv2 Advertisements: sent 0 (errors 0) - rcvd 0
  Group Discarded Packets: 0
    VRRPv2 incompatibility: 0
    IP Address Owner conflicts: 0
    Invalid address count: 0
    IP address configuration mismatch : 0
    Invalid Advert Interval: 0
    Adverts received in Init state: 0
    Invalid group other reason: 0
  Group State transition:
    Init to master: 0
    Init to backup: 1 (Last change Sun Mar 13 19:52:56.874)
    Backup to master: 1 (Last change Sun Mar 13 19:53:00.484)
    Master to backup: 0
    Master to init: 0
    Backup to init: 0

Device# exit

```

## Additional References

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Master Commands List, All Releases</a>
FHRP commands	<a href="#">First Hop Redundancy Protocols Command Reference</a>
Configuring VRRPv2	<i>Configuring VRRP</i>
VRRPv3 Commands	For complete syntax and usage information for the commands used in this chapter.

### Standards and RFCs

Standard/RFC	Title
RFC5798	<i>Virtual Router Redundancy Protocol</i>

### Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

## Feature Information for VRRPv3 Protocol Support

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

Table 30: Feature Information for VRRPv3 Protocol Support

Feature Name	Releases	Feature Information
VRRPv3 Protocol Support	Cisco IOS XE 3.6E Cisco IOS XE Everest 16.6.1	<p>VRRP enables a group of devices to form a single virtual device to provide redundancy. The LAN clients can then be configured with the virtual device as their default gateway. The virtual device, representing a group of devices, is also known as a VRRP group. The VRRPv3 Protocol Support feature provides the capability to support IPv4 and IPv6 addresses.</p> <p>In Cisco IOS Release Cisco IOS XE Release 3.6E, this feature is supported on the following platforms:</p> <p>The following commands were introduced or modified: <b>fhrrp delay</b>, <b>show vrrp</b>, <b>vrrp address-family</b>.</p> <p>This feature was introduced.</p>

## Glossary

**Virtual IP address owner**—The VRRP device that owns the IP address of the virtual device. The owner is the device that has the virtual device address as its physical interface address.

**Virtual device**—One or more VRRP devices that form a group. The virtual device acts as the default gateway device for LAN clients. The virtual device is also known as a VRRP group.

**Virtual device backup**—One or more VRRP devices that are available to assume the role of forwarding packets if the virtual device master fails.

**Virtual device master**—The VRRP device that is currently responsible for forwarding packets sent to the IP addresses of the virtual device. Usually, the virtual device master also functions as the IP address owner.

**VRRP device**—A device that is running VRRP.



## CHAPTER 26

# Configuring GLBP

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## Configuring GLBP

Gateway Load Balancing Protocol (GLBP) protects data traffic from a failed device or circuit, like Hot Standby Router Protocol (HSRP) and Virtual Router Redundancy Protocol (VRRP), while allowing packet load sharing between a group of redundant devices.

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Restrictions for GLBP

Enhanced Object Tracking (EOT) is not stateful switchover (SSO)-aware and cannot be used with GLBP in SSO mode.

## Prerequisites for GLBP

Before configuring GLBP, ensure that the devices can support multiple MAC addresses on the physical interfaces. For each GLBP forwarder to be configured, an additional MAC address is used.

# Information About GLBP

## GLBP Overview

GLBP provides automatic device backup for IP hosts configured with a single default gateway on an IEEE 802.3 LAN. Multiple first-hop devices on the LAN combine to offer a single virtual first-hop IP device while sharing the IP packet forwarding load. Other devices on the LAN act as redundant GLBP devices that will become active if any of the existing forwarding devices fail.

GLBP performs a similar function for the user as HSRP and VRRP. HSRP and VRRP allow multiple devices to participate in a virtual device group configured with a virtual IP address. One member is elected to be the active device to forward packets sent to the virtual IP address for the group. The other devices in the group are redundant until the active device fails. These standby devices have unused bandwidth that the protocol is not using. Although multiple virtual device groups can be configured for the same set of devices, the hosts must be configured for different default gateways, which results in an extra administrative burden. The advantage of GLBP is that it additionally provides load balancing over multiple devices (gateways) using a single virtual IP address and multiple virtual MAC addresses. The forwarding load is shared among all devices in a GLBP group rather than being handled by a single device while the other devices stand idle. Each host is configured with the same virtual IP address, and all devices in the virtual device group participate in forwarding packets. GLBP members communicate between each other through hello messages sent every 3 seconds to the multicast address 224.0.0.102, UDP port 3222 (source and destination).

### GLBP Packet Types

GLBP uses 3 different packet types to operate. The packet types are Hello, Request, and Reply. The Hello packet is used to advertise protocol information. Hello packets are multicast, and are sent when any virtual gateway or virtual forwarder is in Speak, Standby or Active state. Request and Reply packets are used for virtual MAC assignment. They are both unicast messages to and from the active virtual gateway (AVG).

## GLBP Active Virtual Gateway

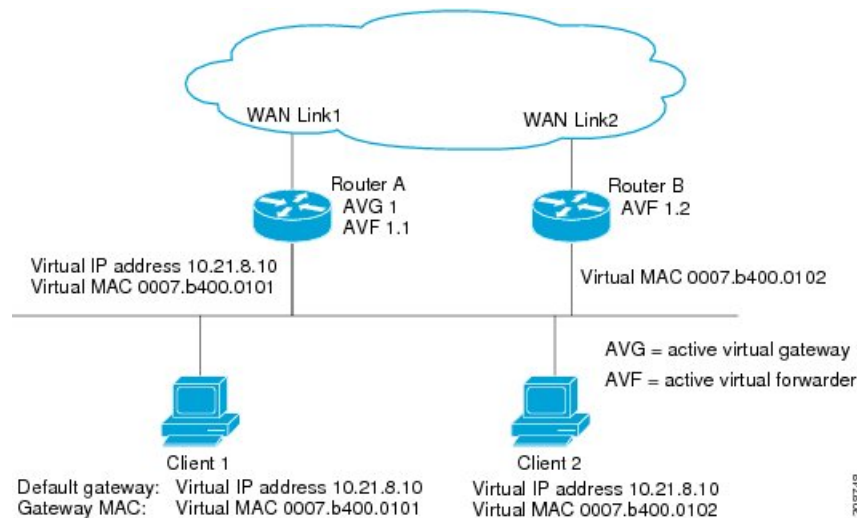
Members of a GLBP group elect one gateway to be the active virtual gateway (AVG) for that group. Other group members provide backup for the AVG if the AVG becomes unavailable. The AVG assigns a virtual MAC address to each member of the GLBP group. Each gateway assumes responsibility for forwarding packets sent to the virtual MAC address assigned to it by the AVG. These gateways are known as active virtual forwarders (AVFs) for their virtual MAC address.

The AVG is also responsible for answering Address Resolution Protocol(ARP) requests for the virtual IP address. Load sharing is achieved by the AVG replying to the ARP requests with different virtual MAC addresses.

When the **no glbp load-balancing** command is configured, if the AVG does not have an AVF, it preferentially responds to ARP requests with the MAC address of the first listening virtual forwarder (VF), which will cause traffic to route via another gateway until that VF migrates back to being the current AVG.

In the figure below, Router A (or Device A) is the AVG for a GLBP group, and is responsible for the virtual IP address 10.21.8.10. Router A is also an AVF for the virtual MAC address 0007.b400.0101. Router B (or Device B) is a member of the same GLBP group and is designated as the AVF for the virtual MAC address 0007.b400.0102. Client 1 has a default gateway IP address of 10.21.8.10 and a gateway MAC address of 0007.b400.0101. Client 2 shares the same default gateway IP address but receives the gateway MAC address 0007.b400.0102 because Router B is sharing the traffic load with Router A.

Figure 20: GLBP Topology



If Router A becomes unavailable, Client 1 will not lose access to the WAN because Router B will assume responsibility for forwarding packets sent to the virtual MAC address of Router A, and for responding to packets sent to its own virtual MAC address. Router B will also assume the role of the AVG for the entire GLBP group. Communication for the GLBP members continues despite the failure of a device in the GLBP group.

## GLBP Virtual MAC Address Assignment

A GLBP group allows up to four virtual MAC addresses per group. The AVG is responsible for assigning the virtual MAC addresses to each member of the group. Other group members request a virtual MAC address after they discover the AVG through hello messages. Gateways are assigned the next MAC address in sequence. A virtual forwarder that is assigned a virtual MAC address by the AVG is known as a primary virtual forwarder. Other members of the GLBP group learn the virtual MAC addresses from hello messages. A virtual forwarder that has learned the virtual MAC address is referred to as a secondary virtual forwarder.

## GLBP Virtual Gateway Redundancy

GLBP operates virtual gateway redundancy in the same way as HSRP. One gateway is elected as the AVG, another gateway is elected as the standby virtual gateway, and the remaining gateways are placed in a listen state.

If an AVG fails, the standby virtual gateway will assume responsibility for the virtual IP address. A new standby virtual gateway is then elected from the gateways in the listen state.

## GLBP Virtual Forwarder Redundancy

Virtual forwarder redundancy is similar to virtual gateway redundancy with an AVF. If the AVF fails, one of the secondary virtual forwarders in the listen state assumes responsibility for the virtual MAC address.

The new AVF is also a primary virtual forwarder for a different forwarder number. GLBP migrates hosts away from the old forwarder number using two timers that start as soon as the gateway changes to the active virtual forwarder state. GLBP uses the hello messages to communicate the current state of the timers.

The redirect time is the interval during which the AVG continues to redirect hosts to the old virtual forwarder MAC address. When the redirect time expires, the AVG stops using the old virtual forwarder MAC address

in ARP replies, although the virtual forwarder will continue to forward packets that were sent to the old virtual forwarder MAC address.

The secondary holdtime is the interval during which the virtual forwarder is valid. When the secondary holdtime expires, the virtual forwarder is removed from all gateways in the GLBP group. The expired virtual forwarder number becomes eligible for reassignment by the AVG.

## GLBP Gateway Priority

GLBP gateway priority determines the role that each GLBP gateway plays and what happens if the AVG fails.

Priority also determines if a GLBP device functions as a backup virtual gateway and the order of ascendancy to becoming an AVG if the current AVG fails. You can configure the priority of each backup virtual gateway with a value of 1 through 255 using the **glbp priority** command.

In the "GLBP Topology" figure, if Router A (or Device A)—the AVG in a LAN topology—fails, an election process takes place to determine which backup virtual gateway should take over. In this example, Router B (or Device B) is the only other member in the group so it will automatically become the new AVG. If another device existed in the same GLBP group with a higher priority, then the device with the higher priority would be elected. If both devices have the same priority, the backup virtual gateway with the higher IP address would be elected to become the active virtual gateway.

By default, the GLBP virtual gateway preemptive scheme is disabled. A backup virtual gateway can become the AVG only if the current AVG fails, regardless of the priorities assigned to the virtual gateways. You can enable the GLBP virtual gateway preemptive scheme using the **glbp preempt** command. Preemption allows a backup virtual gateway to become the AVG, if the backup virtual gateway is assigned a higher priority than the current AVG.

## GLBP Gateway Weighting and Tracking

GLBP uses a weighting scheme to determine the forwarding capacity of each device in the GLBP group. The weighting assigned to a device in the GLBP group can be used to determine whether it will forward packets and, if so, the proportion of hosts in the LAN for which it will forward packets. Thresholds can be set to disable forwarding when the weighting for a GLBP group falls below a certain value, and when it rises above another threshold, forwarding is automatically reenabled.

The GLBP group weighting can be automatically adjusted by tracking the state of an interface within the device. If a tracked interface goes down, the GLBP group weighting is reduced by a specified value. Different interfaces can be tracked to decrement the GLBP weighting by varying amounts.

By default, the GLBP virtual forwarder preemptive scheme is enabled with a delay of 30 seconds. A backup virtual forwarder can become the AVF if the current AVF weighting falls below the low weighting threshold for 30 seconds. You can disable the GLBP forwarder preemptive scheme using the **no glbp forwarder preempt** command or change the delay using the **glbp forwarder preempt delay minimum** command.

## GLBP MD5 Authentication

GLBP MD5 authentication uses the industry-standard MD5 algorithm for improved reliability and security. MD5 authentication provides greater security than the alternative plain text authentication scheme and protects against spoofing software.

MD5 authentication allows each GLBP group member to use a secret key to generate a keyed MD5 hash that is part of the outgoing packet. A keyed hash of an incoming packet is generated and, if the hash within the incoming packet does not match the generated hash, the packet is ignored.



The key for the MD5 hash can either be given directly in the configuration using a key string or supplied indirectly through a key chain. The key string cannot exceed 100 characters in length.

A device will ignore incoming GLBP packets from devices that do not have the same authentication configuration for a GLBP group. GLBP has three authentication schemes:

- No authentication
- Plain text authentication
- MD5 authentication

GLBP packets will be rejected in any of the following cases:

- The authentication schemes differ on the device and in the incoming packet.
- MD5 digests differ on the device and in the incoming packet.
- Text authentication strings differ on the device and in the incoming packet.

## ISSU-GLBP

This feature is not supported on the C9500-12Q, C9500-16X, C9500-24Q, C9500-40X models of the Cisco Catalyst 9500 Series Switches. GLBP supports In Service Software Upgrade (ISSU). ISSU allows a high-availability (HA) system to run in Stateful Switchover (SSO) mode even when different versions of Cisco IOS software are running on the active and standby Route Processors (RPs) or line cards.

ISSU provides the ability to upgrade or downgrade from one supported Cisco IOS release to another while continuing to forward packets and maintain sessions, thereby reducing planned outage time. The ability to upgrade or downgrade is achieved by running different software versions on the active RP and standby RP for a short period of time to maintain state information between RPs. This feature allows the system to switch over to a secondary RP running upgraded (or downgraded) software and continue forwarding packets without session loss and with minimal or no packet loss. This feature is enabled by default.

## GLBP SSO

This feature is not supported on the C9500-12Q, C9500-16X, C9500-24Q, C9500-40X models of the Cisco Catalyst 9500 Series Switches. With the introduction of the GLBP SSO functionality, GLBP is stateful switchover (SSO) aware. GLBP can detect when a device is failing over to the secondary router processor (RP) and continue in its current group state.

SSO functions in networking devices (usually edge devices) that support dual RPs. SSO provides RP redundancy by establishing one of the RPs as the active processor and the other RP as the standby processor. SSO also synchronizes critical state information between the RPs so that network state information is dynamically maintained between RPs.

Without SSO-awareness, if GLBP is deployed on a device with redundant RPs, a switchover of roles between the active RP and the standby RP results in the device relinquishing its activity as a GLBP group member and then rejoining the group as if it had been reloaded. The GLBP SSO feature enables GLBP to continue its activities as a group member during a switchover. GLBP state information between redundant RPs is maintained so that the standby RP can continue the device's activities within the GLBP during and after a switchover.

This feature is enabled by default. To disable this feature, use the command **no glbp sso** in global configuration mode.

## GLBP Benefits

### Load Sharing

You can configure GLBP in such a way that traffic from LAN clients can be shared by multiple devices, thereby sharing the traffic load more equitably among available devices.

### Multiple Virtual Devices

GLBP supports up to 1024 virtual devices (GLBP groups) on each physical interface of a device and up to four virtual forwarders per group.

### Preemption

The redundancy scheme of GLBP enables you to preempt an active virtual gateway (AVG) with a higher priority backup virtual gateway that has become available. Forwarder preemption works in a similar way, except that forwarder preemption uses weighting instead of priority and is enabled by default.

### Authentication

GLBP supports the industry-standard message digest 5 (MD5) algorithm for improved reliability, security, and protection against GLBP-spoofing software. A device within a GLBP group with a different authentication string than other devices will be ignored by other group members. You can alternatively use a simple text password authentication scheme between GLBP group members to detect configuration errors.

## How to Configure GLBP

### Customizing GLBP

Customizing the behavior of GLBP is optional. Be aware that as soon as you enable a GLBP group, that group is operating. It is possible that if you first enable a GLBP group before customizing GLBP, the device could take over control of the group and become the AVG before you have finished customizing the feature. Therefore, if you plan to customize GLBP, it is a good idea to do so before enabling GLBP.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>type number</i></b> <b>Example:</b>	Specifies an interface type and number, and enters interface configuration mode.

	Command or Action	Purpose
	<pre>Device(config)# interface GigabitEthernet 1/0/1</pre>	
<b>Step 4</b>	<p><b>ip address</b> <i>ip-address mask</i> [<b>secondary</b>]</p> <p><b>Example:</b></p> <pre>Device(config-if)# ip address 10.21.8.32 255.255.255.0</pre>	Specifies a primary or secondary IP address for an interface.
<b>Step 5</b>	<p><b>glbp group timers</b> [<b>msec</b>] <i>hellotime</i> [<b>msec</b>] <i>holdtime</i></p> <p><b>Example:</b></p> <pre>Device(config-if)# glbp 10 timers 5 18</pre>	<p>Configures the interval between successive hello packets sent by the AVG in a GLBP group.</p> <ul style="list-style-type: none"> <li>The <i>holdtime</i> argument specifies the interval in seconds before the virtual gateway and virtual forwarder information in the hello packet is considered invalid.</li> <li>The optional <b>msec</b> keyword specifies that the following argument will be expressed in milliseconds, instead of the default seconds.</li> </ul>
<b>Step 6</b>	<p><b>glbp group timers redirect</b> <i>redirect timeout</i></p> <p><b>Example:</b></p> <pre>Device(config-if)# glbp 10 timers redirect 1800 28800</pre>	<p>Configures the time interval during which the AVG continues to redirect clients to an AVF. The default is 600 seconds (10 minutes).</p> <ul style="list-style-type: none"> <li>The <i>timeout</i> argument specifies the interval in seconds before a secondary virtual forwarder becomes invalid. The default is 14,400 seconds (4 hours).</li> </ul> <p><b>Note</b> The zero value for the <i>redirect</i> argument cannot be removed from the range of acceptable values because preexisting configurations of Cisco IOS software already using the zero value could be negatively affected during an upgrade. However, a zero setting is not recommended and, if used, results in a redirect timer that never expires. If the redirect timer does not expire, and the device fails, new hosts continue to be assigned to the failed device instead of being redirected to the backup.</p>

	Command or Action	Purpose
Step 7	<p><b>glbp group load-balancing</b> [<b>host-dependent</b>   <b>round-robin</b>   <b>weighted</b>]</p> <p><b>Example:</b></p> <pre>Device(config-if)# glbp 10 load-balancing host-dependent</pre>	Specifies the method of load balancing used by the GLBP AVG.
Step 8	<p><b>glbp group priority level</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# glbp 10 priority 254</pre>	<p>Sets the priority level of the gateway within a GLBP group.</p> <ul style="list-style-type: none"> <li>The default value is 100.</li> </ul>
Step 9	<p><b>glbp group preempt</b> [<b>delay minimum seconds</b>]</p> <p><b>Example:</b></p> <pre>Device(config-if)# glbp 10 preempt delay minimum 60</pre>	<p>Configures the device to take over as AVG for a GLBP group if it has a higher priority than the current AVG.</p> <ul style="list-style-type: none"> <li>This command is disabled by default.</li> <li>Use the optional <b>delay</b> and <b>minimum</b> keywords and the <i>seconds</i> argument to specify a minimum delay interval in seconds before preemption of the AVG takes place.</li> </ul>
Step 10	<p><b>glbp group client-cache maximum number</b> [<b>timeout minutes</b>]</p> <p><b>Example:</b></p> <pre>Device(config-if)# glbp 10 client-cache maximum 1200 timeout 245</pre>	<p>(Optional) Enables the GLBP client cache.</p> <ul style="list-style-type: none"> <li>This command is disabled by default.</li> <li>Use the <i>number</i> argument to specify the maximum number of clients the cache will hold for this GLBP group. The range is from 8 to 2000.</li> <li>Use the optional <b>timeout minutes</b> keyword and argument pair to configure the maximum amount of time a client entry can stay in the GLBP client cache after the client information was last updated. The range is from 1 to 1440 minutes (one day).</li> </ul> <p><b>Note</b> For IPv4 networks, Cisco recommends setting a GLBP client cache timeout value that is slightly longer than the maximum expected end-host Address Resolution Protocol (ARP) cache timeout value.</p>

	Command or Action	Purpose
<b>Step 11</b>	<b>glbp group name redundancy-name</b> <b>Example:</b> <pre>Device(config-if)# glbp 10 name abc123</pre>	Enables IP redundancy by assigning a name to the GLBP group. <ul style="list-style-type: none"> <li>The GLBP redundancy client must be configured with the same GLBP group name so the redundancy client and the GLBP group can be connected.</li> </ul>
<b>Step 12</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-if)# exit</pre>	Exits interface configuration mode, and returns the device to global configuration mode.
<b>Step 13</b>	<b>no glbp sso</b> <b>Example:</b> <pre>Device(config)# no glbp sso</pre>	(Optional) Disables GLBP support of SSO.

## Configuring GLBP MD5 Authentication Using a Key String

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>interface type number</b> <b>Example:</b> <pre>Device(config)# interface GigabitEthernet 1/0/1</pre>	Configures an interface type and enters interface configuration mode.
<b>Step 4</b>	<b>ip address ip-address mask [secondary]</b> <b>Example:</b> <pre>Device(config-if)# ip address 10.0.0.1 255.255.255.0</pre>	Specifies a primary or secondary IP address for an interface.
<b>Step 5</b>	<b>glbp group-number authentication md5 key-string [ 0   7 ] key</b>	Configures an authentication key for GLBP MD5 authentication.

	Command or Action	Purpose
	<b>Example:</b>  Device(config-if)# glbp 1 authentication md5 key-string d00b4r987654321a	<ul style="list-style-type: none"> <li>The key string cannot exceed 100 characters in length.</li> <li>No prefix to the <i>key</i> argument or specifying <b>0</b> means the key is unencrypted.</li> <li>Specifying <b>7</b> means the key is encrypted. The key-string authentication key will automatically be encrypted if the <b>service password-encryption</b> global configuration command is enabled.</li> </ul>
<b>Step 6</b>	<b>glbp group-number ip [ip-address [secondary]]</b>  <b>Example:</b>  Device(config-if)# glbp 1 ip 10.0.0.10	Enables GLBP on an interface and identifies the primary IP address of the virtual gateway.
<b>Step 7</b>	Repeat Steps 1 through 6 on each device that will communicate.	—
<b>Step 8</b>	<b>end</b>  <b>Example:</b>  Device(config-if)# end	Returns to privileged EXEC mode.
<b>Step 9</b>	<b>show glbp</b>  <b>Example:</b>  Device# show glbp	(Optional) Displays GLBP information. <ul style="list-style-type: none"> <li>Use this command to verify your configuration. The key string and authentication type will be displayed if configured.</li> </ul>

## Configuring GLBP MD5 Authentication Using a Key Chain

Perform this task to configure GLBP MD5 authentication using a key chain. Key chains allow a different key string to be used at different times according to the key chain configuration. GLBP will query the appropriate key chain to obtain the current live key and key ID for the specified key chain.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# configure terminal	
<b>Step 3</b>	<b>key chain</b> <i>name-of-chain</i> <b>Example:</b> Device(config)# key chain glbp2	Enables authentication for routing protocols and identifies a group of authentication keys and enters key-chain configuration mode.
<b>Step 4</b>	<b>key</b> <i>key-id</i> <b>Example:</b> Device(config-keychain)# key 100	Identifies an authentication key on a key chain. <ul style="list-style-type: none"> <li>The value for the <i>key-id</i> argument must be a number.</li> </ul>
<b>Step 5</b>	<b>key-string</b> <i>string</i> <b>Example:</b> Device(config-keychain-key)# key-string abc123	Specifies the authentication string for a key and enters key-chain key configuration mode. <ul style="list-style-type: none"> <li>The value for the <i>string</i> argument can be 1 to 80 uppercase or lowercase alphanumeric characters; the first character cannot be a numeral.</li> </ul>
<b>Step 6</b>	<b>exit</b> <b>Example:</b> Device(config-keychain-key)# exit	Returns to key-chain configuration mode.
<b>Step 7</b>	<b>exit</b> <b>Example:</b> Device(config-keychain)# exit	Returns to global configuration mode.
<b>Step 8</b>	<b>interface</b> <i>type number</i> <b>Example:</b> Device(config)# interface GigabitEthernet 1/0/1	Configures an interface type and enters interface configuration mode.
<b>Step 9</b>	<b>ip address</b> <i>ip-address mask</i> [ <b>secondary</b> ] <b>Example:</b> Device(config-if)# ip address 10.21.0.1 255.255.255.0	Specifies a primary or secondary IP address for an interface.
<b>Step 10</b>	<b>glbp</b> <i>group-number authentication md5 key-chain name-of-chain</i> <b>Example:</b> Device(config-if)# glbp 1 authentication md5 key-chain glbp2	Configures an authentication MD5 key chain for GLBP MD5 authentication. <ul style="list-style-type: none"> <li>The key chain name must match the name specified in Step 3.</li> </ul>

	Command or Action	Purpose
<b>Step 11</b>	<b>glbp group-number ip</b> [ <i>ip-address</i> [ <i>secondary</i> ]]  <b>Example:</b>  Device(config-if)# glbp 1 ip 10.21.0.12	Enables GLBP on an interface and identifies the primary IP address of the virtual gateway.
<b>Step 12</b>	Repeat Steps 1 through 10 on each device that will communicate.	—
<b>Step 13</b>	<b>end</b>  <b>Example:</b>  Device(config-if)# end	Returns to privileged EXEC mode.
<b>Step 14</b>	<b>show glbp</b>  <b>Example:</b>  Device# show glbp	(Optional) Displays GLBP information.  • Use this command to verify your configuration. The key chain and authentication type will be displayed if configured.
<b>Step 15</b>	<b>show key chain</b>  <b>Example:</b>  Device# show key chain	(Optional) Displays authentication key information.

## Configuring GLBP Text Authentication

Text authentication provides minimal security. Use MD5 authentication if security is required.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface type number</b>  <b>Example:</b>  Device(config)# interface GigabitEthernet 1/0/1	Configures an interface type and enters interface configuration mode.



	Command or Action	Purpose
<b>Step 4</b>	<b>ip address</b> <i>ip-address mask</i> [ <b>secondary</b> ] <b>Example:</b>  Device(config-if)# ip address 10.0.0.1 255.255.255.0	Specifies a primary or secondary IP address for an interface.
<b>Step 5</b>	<b>glbp group-number authentication text string</b> <b>Example:</b>  Device(config-if)# glbp 10 authentication text stringxyz	Authenticates GLBP packets received from other devices in the group. <ul style="list-style-type: none"> <li>• If you configure authentication, all devices within the GLBP group must use the same authentication string.</li> </ul>
<b>Step 6</b>	<b>glbp group-number ip</b> [ <i>ip-address</i> [ <b>secondary</b> ]] <b>Example:</b>  Device(config-if)# glbp 1 ip 10.0.0.10	Enables GLBP on an interface and identifies the primary IP address of the virtual gateway.
<b>Step 7</b>	Repeat Steps 1 through 6 on each device that will communicate.	—
<b>Step 8</b>	<b>end</b> <b>Example:</b>  Device(config-if)# end	Returns to privileged EXEC mode.
<b>Step 9</b>	<b>show glbp</b> <b>Example:</b>  Device# show glbp	(Optional) Displays GLBP information. <ul style="list-style-type: none"> <li>• Use this command to verify your configuration.</li> </ul>

## Configuring GLBP Weighting Values and Object Tracking

GLBP weighting is used to determine whether a GLBP group can act as a virtual forwarder. Initial weighting values can be set and optional thresholds specified. Interface states can be tracked and a decrement value set to reduce the weighting value if the interface goes down. When the GLBP group weighting drops below a specified value, the group will no longer be an active virtual forwarder. When the weighting rises above a specified value, the group can resume its role as an active virtual forwarder.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>track <i>object-number</i> interface <i>type number</i> {<i>line-protocol</i>   {<i>ip</i>   <i>ipv6</i>} <i>routing</i>}</b> <b>Example:</b> <pre>Device(config)# track 2 interface GigabitEthernet 1/0/1 ip routing</pre>	Configures an interface to be tracked where changes in the state of the interface affect the weighting of a GLBP gateway, and enters tracking configuration mode. <ul style="list-style-type: none"> <li>• This command configures the interface and corresponding object number to be used with the <b>glbp weighting track</b> command.</li> <li>• The <b>line-protocol</b> keyword tracks whether the interface is up. The <b>ip routing</b> keywords also check that IP routing is enabled on the interface, and an IP address is configured.</li> </ul>
<b>Step 4</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-track)# exit</pre>	Returns to global configuration mode.
<b>Step 5</b>	<b>interface <i>type number</i></b> <b>Example:</b> <pre>Device(config)# interface GigabitEthernet 1/0/1</pre>	Enters interface configuration mode.
<b>Step 6</b>	<b>glbp group weighting <i>maximum</i> [<i>lower lower</i>] [<i>upper upper</i>]</b> <b>Example:</b> <pre>Device(config-if)# glbp 10 weighting 110 lower 95 upper 105</pre>	Specifies the initial weighting value, and the upper and lower thresholds, for a GLBP gateway.
<b>Step 7</b>	<b>glbp group weighting track <i>object-number</i> [<i>decrement value</i>]</b> <b>Example:</b> <pre>Device(config-if)# glbp 10 weighting track 2 decrement 5</pre>	Specifies an object to be tracked that affects the weighting of a GLBP gateway. <ul style="list-style-type: none"> <li>• The <i>value</i> argument specifies a reduction in the weighting of a GLBP gateway when a tracked object fails.</li> </ul>
<b>Step 8</b>	<b>glbp group forwarder preempt [<i>delay minimum seconds</i>]</b> <b>Example:</b>	Configures the device to take over as AVF for a GLBP group if the current AVF for a GLBP group falls below its low weighting threshold.

	Command or Action	Purpose
	<pre>Device(config-if)# glbp 10 forwarder preempt delay minimum 60</pre>	<ul style="list-style-type: none"> <li>This command is enabled by default with a delay of 30 seconds.</li> <li>Use the optional <b>delay</b> and <b>minimum</b> keywords and the <i>seconds</i> argument to specify a minimum delay interval in seconds before preemption of the AVF takes place.</li> </ul>
<b>Step 9</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# exit</pre>	Returns to privileged EXEC mode.
<b>Step 10</b>	<p><b>show track</b> [<i>object-number</i>   <b>brief</b>] [<b>interface</b> [<b>brief</b>]   <b>ip route</b> [<b>brief</b>]   <b>resolution</b>   <b>timers</b>]</p> <p><b>Example:</b></p> <pre>Device# show track 2</pre>	Displays tracking information.

## Troubleshooting GLBP

GLBP introduces five privileged EXEC mode commands to enable display of diagnostic output concerning various events relating to the operation of GLBP. The **debug condition glbp**, **debug glbp errors**, **debug glbp events**, **debug glbp packets**, and **debug glbp terse** commands are intended only for troubleshooting purposes because the volume of output generated by the software can result in severe performance degradation on the device. Perform this task to minimize the impact of using the **debug glbp** commands.

This procedure will minimize the load on the device created by the **debug condition glbp** or **debug glbp** command because the console port is no longer generating character-by-character processor interrupts. If you cannot connect to a console directly, you can run this procedure via a terminal server. If you must break the Telnet connection, however, you may not be able to reconnect because the device may be unable to respond due to the processor load of generating the debugging output.

### Before you begin

This task requires a device running GLBP to be attached directly to a console.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p>	Enters global configuration mode.

	Command or Action	Purpose
	Device# configure terminal	
<b>Step 3</b>	<b>no logging console</b> <b>Example:</b> Device(config)# no logging console	Disables all logging to the console terminal. <ul style="list-style-type: none"> <li>To reenale logging to the console, use the <b>logging console</b> command in global configuration mode.</li> </ul>
<b>Step 4</b>	Use Telnets to access a device port and repeat Steps 1 and 2.	Enters global configuration mode in a recursive Telnets session, which allows the output to be redirected away from the console port.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# end	Exits to privileged EXEC mode.
<b>Step 6</b>	<b>terminal monitor</b> <b>Example:</b> Device# terminal monitor	Enables logging output on the virtual terminal.
<b>Step 7</b>	<b>debug condition glbp interface-type interface-number group [forwarder]</b> <b>Example:</b> Device# debug condition glbp GigabitEthernet 0/0/0 1	Displays debugging messages about GLBP conditions. <ul style="list-style-type: none"> <li>Try to enter only specific <b>debug condition glbp</b> or <b>debug glbp</b> commands to isolate the output to a certain subcomponent and minimize the load on the processor. Use appropriate arguments and keywords to generate more detailed debug information on specified subcomponents.</li> <li>Enter the specific <b>no debug condition glbp</b> or <b>no debug glbp</b> command when you are finished.</li> </ul>
<b>Step 8</b>	<b>terminal no monitor</b> <b>Example:</b> Device# terminal no monitor	Disables logging on the virtual terminal.

## Configuration Examples for GLBP

### Example: Customizing GLBP Configuration

```
Device(config)# interface GigabitEthernet 1/0/1
```

```

Device(config-if)# ip address 10.21.8.32 255.255.255.0
Device(config-if)# glbp 10 timers 5 18
Device(config-if)# glbp 10 timers redirect 1800 28800
Device(config-if)# glbp 10 load-balancing host-dependent
Device(config-if)# glbp 10 priority 254
Device(config-if)# glbp 10 preempt delay minimum 60

Device(config-if)# glbp 10 client-cache maximum 1200 timeout 245

```

## Example: Configuring GLBP MD5 Authentication Using Key Strings

The following example shows how to configure GLBP MD5 authentication using a key string:

```

Device(config)# interface GigabitEthernet 1/0/1
Device(config-if)# ip address 10.0.0.1 255.255.255.0
Device(config-if)# glbp 2 authentication md5 key-string ThisStringIsTheSecretKey
Device(config-if)# glbp 2 ip 10.0.0.10

```

## Example: Configuring GLBP MD5 Authentication Using Key Chains

In the following example, GLBP queries the key chain “AuthenticateGLBP” to obtain the current live key and key ID for the specified key chain:

```

Device(config)# key chain AuthenticateGLBP
Device(config-keychain)# key 1
Device(config-keychain-key)# key-string ThisIsASecretKey
Device(config-keychain-key)# exit
Device(config-keychain)# exit
Device(config)# interface GigabitEthernet 1/0/1
Device(config-if)# ip address 10.0.0.1 255.255.255.0
Device(config-if)# glbp 2 authentication md5 key-chain AuthenticateGLBP
Device(config-if)# glbp 2 ip 10.0.0.10

```

## Example: Configuring GLBP Text Authentication

```

Device(config)# interface GigabitEthernet 0/0/0
Device(config-if)# ip address 10.21.8.32 255.255.255.0
Device(config-if)# glbp 10 authentication text stringxyz
Device(config-if)# glbp 10 ip 10.21.8.10

```

## Example: Configuring GLBP Weighting

In the following example, the device is configured to track the IP routing state of the POS interface 5/0/0 and 6/0/0, an initial GLBP weighting with upper and lower thresholds is set, and a weighting decrement value of 10 is set. If POS interface 5/0/0 and 6/0/0 go down, the weighting value of the device is reduced.

```

Device(config)# track 1 interface GigabitEthernet 1/0/1 line-protocol
Device(config)# track 2 interface GigabitEthernet 1/0/3 line-protocol
Device(config)# interface TenGigabitEthernet 0/0/1
Device(config-if)# ip address 10.21.8.32 255.255.255.0
Device(config-if)# glbp 10 weighting 110 lower 95 upper 105
Device(config-if)# glbp 10 weighting track 1 decrement 10
Device(config-if)# glbp 10 weighting track 2 decrement 10

```

## Example: Enabling GLBP Configuration

In the following example, the device is configured to enable GLBP, and the virtual IP address of 10.21.8.10 is specified for GLBP group 10:

```
Device(config)# interface GigabitEthernet 0/0/0
Device(config-if)# ip address 10.21.8.32 255.255.255.0
Device(config-if)# glbp 10 ip 10.21.8.10
```

## Additional References for GLBP

### Related Documents

Related Topic	Document Title
GLBP commands: complete command syntax, command mode, command history, defaults, usage guidelines, and examples.	<a href="#">Cisco IOS IP Application Services Command Reference</a>
In Service Software Upgrade (ISSU) configuration	"In Service Software Upgrade" process module in the <i>Cisco IOS High Availability Configuration Guide</i>
Key chains and key management commands: complete command syntax, command mode, command history, defaults, usage guidelines, and examples	<i>Cisco IOS IP Routing Protocol-Independent Command Reference</i>
Object tracking	"Configuring Enhanced Object Tracking" module
Stateful Switchover	The "Stateful Switchover" module in the <i>Cisco IOS High Availability Configuration Guide</i>
VRRP	"Configuring VRRP" module
HSRP	"Configuring HSRP" module
GLBP Support for IPv6	"FHRP - GLBP Support for IPv6" module

### Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

## Feature Information for GLBP

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

**Table 31: Feature Information for GLBP**

Feature Name	Releases	Feature Configuration Information
Gateway Load Balancing Protocol		<p>GLBP protects data traffic from a failed router or circuit, like HSRP and VRRP, while allowing packet load sharing between a group of redundant routers.</p> <p>In Cisco IOS Release Cisco IOS XE Release 3.6E, this feature is supported on the following platforms:</p> <ul style="list-style-type: none"> <li>• Cisco 5760 Wireless LAN Controller</li> </ul> <p>The following commands were introduced or modified by this feature: <b>glbp forwarder preempt</b>, <b>glbp ip</b>, <b>glbp load-balancing</b>, <b>glbp name</b>, <b>glbp preempt</b>, <b>glbp priority</b>, <b>glbp sso</b>, <b>glbp timers</b>, <b>glbp timers redirect</b>, <b>glbp weighting</b>, <b>glbp weighting track</b>, <b>show glbp</b>.</p>
GLBP MD5 Authentication	Cisco IOS XE 3.6E	<p>MD5 authentication provides greater security than the alternative plain text authentication scheme. MD5 authentication allows each GLBP group member to use a secret key to generate a keyed MD5 hash that is part of the outgoing packet. A keyed hash of an incoming packet is generated and, if the hash within the incoming packet does not match the generated hash, the packet is ignored.</p> <p>In Cisco IOS Release Cisco IOS XE Release 3.6E, this feature is supported on the following platforms:</p> <ul style="list-style-type: none"> <li>• Cisco 5760 Wireless LAN Controller</li> </ul> <p>The following commands were modified by this feature: <b>glbp authentication</b>, <b>show glbp</b>.</p>
ISSU—GLBP		<p>GLBP supports In Service Software Upgrade (ISSU). ISSU allows a high-availability (HA) system to run in Stateful Switchover (SSO) mode even when different versions of Cisco IOS software are running on the active and standby Route Processors (RPs) or line cards.</p> <p>This feature provides customers with the same level of HA functionality for planned outages due to software upgrades as is available with SSO for unplanned outages. That is, the system can switch over to a secondary RP and continue forwarding packets without session loss and with minimal or no packet loss.</p> <p>This feature is enabled by default.</p> <p>There are no new or modified commands for this feature.</p>

Feature Name	Releases	Feature Configuration Information
SSO—GLBP		<p>GLBP is now SSO aware. GLBP can detect when a router is failing over to the secondary RP and continue in its current GLBP group state.</p> <p>Prior to being SSO aware, GLBP was not able to detect that a second RP was installed and configured to take over in the event that the primary RP failed. When the primary failed, the GLBP device would stop participating in the GLBP group and, depending on its role, could trigger another router in the group to take over as the active router. With this enhancement, GLBP detects the failover to the secondary RP and no change occurs to the GLBP group. If the secondary RP fails and the primary is still not available, then the GLBP group detects this and re-elects a new active GLBP router.</p> <p>This feature is enabled by default.</p> <p>The following commands were introduced or modified by this feature: <b>debug glbp events, glbp sso, show glbp.</b></p>

## Glossary

**active RP**—The Route Processor (RP) controls the system, provides network services, runs routing protocols and presents the system management interface.

**AVF**—active virtual forwarder. One virtual forwarder within a GLBP group is elected as active virtual forwarder for a specified virtual MAC address, and it is responsible for forwarding packets sent to that MAC address. Multiple active virtual forwarders can exist for each GLBP group.

**AVG**—active virtual gateway. One virtual gateway within a GLBP group is elected as the active virtual gateway, and is responsible for the operation of the protocol.

**GLBP gateway**—Gateway Load Balancing Protocol gateway. A router or gateway running GLBP. Each GLBP gateway may participate in one or more GLBP groups.

**GLBP group**—Gateway Load Balancing Protocol group. One or more GLBP gateways configured with the same GLBP group number on connected Ethernet interfaces.

**ISSU**—In Service Software Upgrade. A process that allows Cisco IOS XE software to be updated or otherwise modified while packet forwarding continues. In most networks, planned software upgrades are a significant cause of downtime. ISSU allows software to be modified while packet forwarding continues, which increases network availability and reduces downtime caused by planned software upgrades.

**NSF**—nonstop forwarding. The ability of a router to continue to forward traffic to a router that may be recovering from a failure. Also, the ability of a router recovering from a failure to continue to correctly forward traffic sent to it by a peer.

**RP**—Route Processor. A generic term for the centralized control unit in a chassis. Platforms usually use a platform-specific term, such as RSP on the Cisco 7500, the PRE on the Cisco 10000, or the SUP+MSFC on the Cisco 7600.

**RPR**—Route Processor Redundancy. RPR provides an alternative to the High System Availability (HSA) feature. HSA enables a system to reset and use a standby Route Processor (RP) if the active RP fails. Using RPR, you can reduce unplanned downtime because RPR enables a quicker switchover between an active and standby RP if the active RP experiences a fatal error.

**RPR+**—An enhancement to RPR in which the standby RP is fully initialized.



**SSO**—Stateful Switchover. Enables applications and features to maintain state information between an active and standby unit.

**standby RP**—An RP that has been fully initialized and is ready to assume control from the active RP should a manual or fault-induced switchover occur.

**switchover**—An event in which system control and routing protocol execution are transferred from the active RP to the standby RP. Switchover may be a manual operation or may be induced by a hardware or software fault. Switchover may include transfer of the packet forwarding function in systems that combine system control and packet forwarding in an indivisible unit.

**vIP**—virtual IP address. An IPv4 address. There must be only one virtual IP address for each configured GLBP group. The virtual IP address must be configured on at least one GLBP group member. Other GLBP group members can learn the virtual IP address from hello messages.





## PART VII

# IP Multicast Routing

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- [Constraining IP Multicast in Switched Ethernet, on page 507](#)
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- [Configuring MSDP, on page 581](#)
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## CHAPTER 27

# IP Multicast Routing Technology Overview

- [Information About IP Multicast Technology, on page 431](#)

## Information About IP Multicast Technology

### Role of IP Multicast in Information Delivery

IP multicast is a bandwidth-conserving technology that reduces traffic by delivering a single stream of information simultaneously to potentially thousands of businesses and homes. Applications that take advantage of multicast include video conferencing, corporate communications, distance learning, and distribution of software, stock quotes, and news.

IP multicast routing enables a host (source) to send packets to a group of hosts (receivers) anywhere within the IP network by using a special form of IP address called the IP multicast group address. The sending host inserts the multicast group address into the IP destination address field of the packet and IP multicast routers and multilayer switches forward incoming IP multicast packets out all interfaces that lead to the members of the multicast group. Any host, regardless of whether it is a member of a group, can send to a group. However, only the members of a group receive the message.

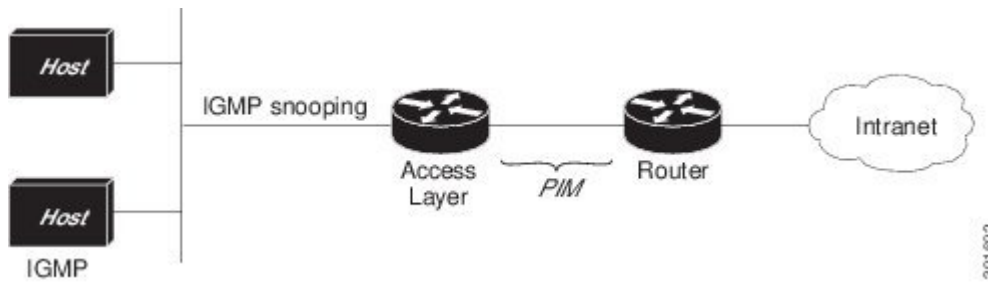
### IP Multicast Routing Protocols

The software supports the following protocols to implement IP multicast routing:

- IGMP is used between hosts on a LAN and the routers (and multilayer devices) on that LAN to track the multicast groups of which hosts are members. To participate in IP multicasting, multicast hosts, routers, and multilayer devices must have the Internet Group Management Protocol (IGMP) operating.
- Protocol Independent Multicast (PIM) is used between routers so that they can track which multicast packets to forward to each other and to their directly connected LANs.
- IGMP Snooping is used for multicasting in a Layer 2 switching environment. It helps reduce the flooding of multicast traffic by dynamically configuring Layer 2 interfaces so that multicast traffic is forwarded to only those interfaces associated with IP multicast devices.

This figure shows where these protocols operate within the IP multicast environment.

Figure 21: IP Multicast Routing Protocols



According to IPv4 multicast standards, the MAC destination multicast address begins with 0100:5e and is appended by the last 23 bits of the IP address. For example, if the IP destination address is 239.1.1.39, the MAC destination address is 0100:5e01:0127.

A multicast packet is unmatched when the destination IPv4 address does not match the destination MAC address. The device forwards the unmatched packet in hardware based upon the MAC address table. If the destination MAC address is not in the MAC address table, the device floods the packet to the all port in the same VLAN as the receiving port.

## Multicast Group Transmission Scheme

IP communication consists of hosts that act as senders and receivers of traffic as shown in the first figure. Senders are called sources. Traditional IP communication is accomplished by a single host source sending packets to another single host (unicast transmission) or to all hosts (broadcast transmission). IP multicast provides a third scheme, allowing a host to send packets to a subset of all hosts (multicast transmission). This subset of receiving hosts is called a multicast group. The hosts that belong to a multicast group are called group members.

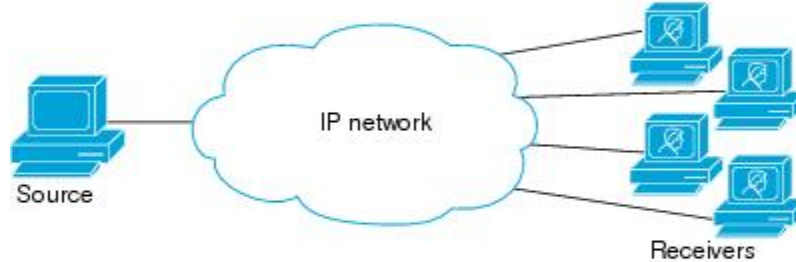
Multicast is based on this group concept. A multicast group is an arbitrary number of receivers that join a group in order to receive a particular data stream. This multicast group has no physical or geographical boundaries--the hosts can be located anywhere on the Internet or on any private internetwork. Hosts that are interested in receiving data from a source to a particular group must join that group. Joining a group is accomplished by a host receiver by way of the Internet Group Management Protocol (IGMP).

In a multicast environment, any host, regardless of whether it is a member of a group, can send to a group. However, only the members of a group can receive packets sent to that group. Multicast packets are delivered to a group using best-effort reliability, just like IP unicast packets.

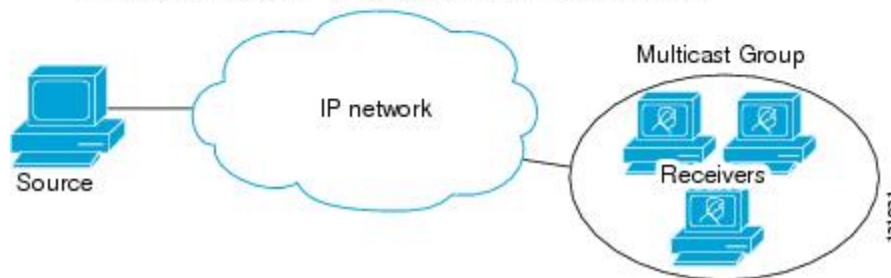
Unicast transmission—One host sends and the other receives.



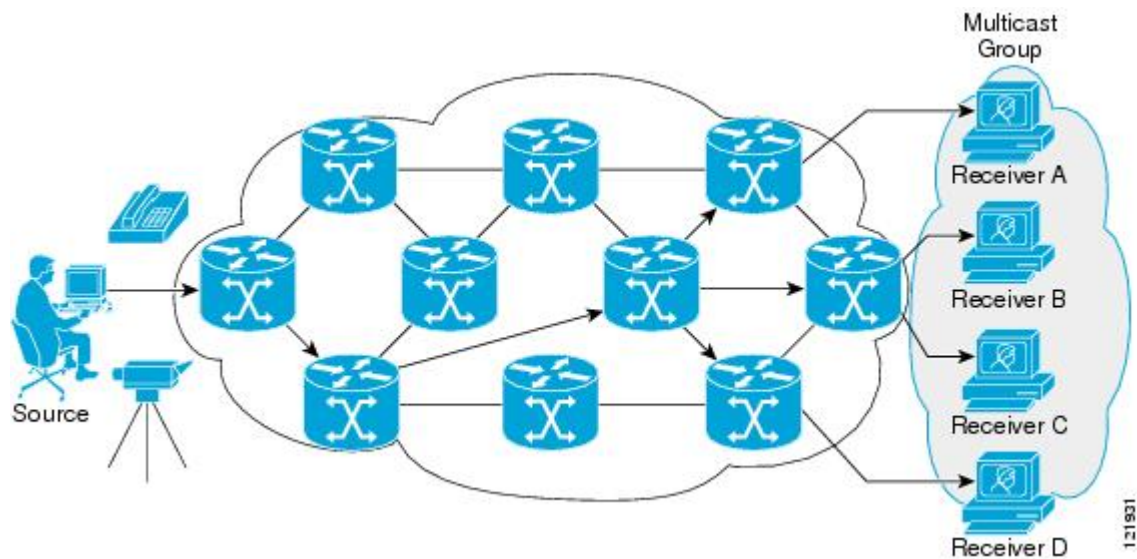
Broadcast transmission—One sender to all receivers.



Multicast transmission—One sender to a group of receivers.



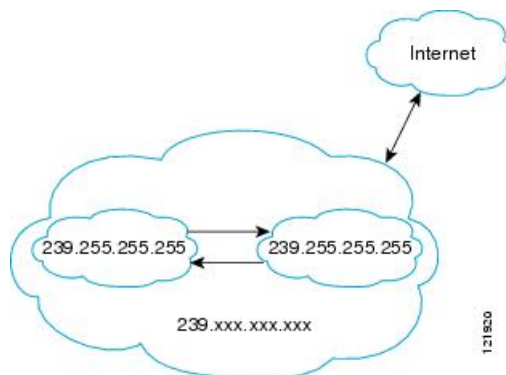
In the next figure, the receivers (the designated multicast group) are interested in receiving the video data stream from the source. The receivers indicate their interest by sending an IGMP host report to the routers in the network. The routers are then responsible for delivering the data from the source to the receivers. The routers use Protocol Independent Multicast (PIM) to dynamically create a multicast distribution tree. The video data stream will then be delivered only to the network segments that are in the path between the source and the receivers.



## IP Multicast Boundary

As shown in the figure, address scoping defines domain boundaries so that domains with RPs that have the same IP address do not leak into each other. Scoping is performed on the subnet boundaries within large domains and on the boundaries between the domain and the Internet.

**Figure 22: Address Scoping at Boundaries**



You can set up an administratively scoped boundary on an interface for multicast group addresses using the **ip multicast boundary** command with the *access-list* argument. A standard access list defines the range of addresses affected. When a boundary is set up, no multicast data packets are allowed to flow across the boundary from either direction. The boundary allows the same multicast group address to be reused in different administrative domains.

The Internet Assigned Numbers Authority (IANA) has designated the multicast address range 239.0.0.0 to 239.255.255.255 as the administratively scoped addresses. This range of addresses can be reused in domains administered by different organizations. They would be considered local, not globally unique.

You can configure the **filter-autorp** keyword to examine and filter Auto-RP discovery and announcement messages at the administratively scoped boundary. Any Auto-RP group range announcements from the Auto-RP packets that are denied by the boundary access control list (ACL) are removed. An Auto-RP group



range announcement is permitted and passed by the boundary only if all addresses in the Auto-RP group range are permitted by the boundary ACL. If any address is not permitted, the entire group range is filtered and removed from the Auto-RP message before the Auto-RP message is forwarded.

## IP Multicast Group Addressing

A multicast group is identified by its multicast group address. Multicast packets are delivered to that multicast group address. Unlike unicast addresses that uniquely identify a single host, multicast IP addresses do not identify a particular host. To receive the data sent to a multicast address, a host must join the group that address identifies. The data is sent to the multicast address and received by all the hosts that have joined the group indicating that they wish to receive traffic sent to that group. The multicast group address is assigned to a group at the source. Network administrators who assign multicast group addresses must make sure the addresses conform to the multicast address range assignments reserved by the Internet Assigned Numbers Authority (IANA).

### IP Class D Addresses

IP multicast addresses have been assigned to the IPv4 Class D address space by IANA. The high-order four bits of a Class D address are 1110. Therefore, host group addresses can be in the range 224.0.0.0 to 239.255.255.255. A multicast address is chosen at the source (sender) for the receivers in a multicast group.



**Note** The Class D address range is used only for the group address or destination address of IP multicast traffic. The source address for multicast datagrams is always the unicast source address.

## IP Multicast Address Scoping

The multicast address range is subdivided to provide predictable behavior for various address ranges and for address reuse within smaller domains. The table provides a summary of the multicast address ranges. A brief summary description of each range follows.

**Table 32: Multicast Address Range Assignments**

Name	Range	Description
Reserved Link-Local Addresses	224.0.0.0 to 224.0.0.255	Reserved for use by network protocols on a local network segment.
Globally Scoped Addresses	224.0.1.0 to 238.255.255.255	Reserved to send multicast data between organizations and across the Internet.
Source Specific Multicast	232.0.0.0 to 232.255.255.255	Reserved for use with the SSM datagram delivery model where data is forwarded only to receivers that have explicitly joined the group.
GLOP Addresses	233.0.0.0 to 233.255.255.255	Reserved for statically defined addresses by organizations that already have an assigned autonomous system (AS) domain number.
Limited Scope Address	239.0.0.0 to 239.255.255.255	Reserved as administratively or limited scope addresses for use in private multicast domains.

### Reserved Link-Local Addresses

The IANA has reserved the range 224.0.0.0 to 224.0.0.255 for use by network protocols on a local network segment. Packets with an address in this range are local in scope and are not forwarded by IP routers. Packets with link local destination addresses are typically sent with a time-to-live (TTL) value of 1 and are not forwarded by a router.

Within this range, reserved link-local addresses provide network protocol functions for which they are reserved. Network protocols use these addresses for automatic router discovery and to communicate important routing information. For example, Open Shortest Path First (OSPF) uses the IP addresses 224.0.0.5 and 224.0.0.6 to exchange link-state information.

IANA assigns single multicast address requests for network protocols or network applications out of the 224.0.1.xxx address range. Multicast routers forward these multicast addresses.



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**Note** All the packets with reserved link-local addresses are punted to CPU by default in the ASR 903 RSP2 Module.

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### Globally Scoped Addresses

Addresses in the range 224.0.1.0 to 238.255.255.255 are called globally scoped addresses. These addresses are used to send multicast data between organizations across the Internet. Some of these addresses have been reserved by IANA for use by multicast applications. For example, the IP address 224.0.1.1 is reserved for Network Time Protocol (NTP).

### Source Specific Multicast Addresses

Addresses in the range 232.0.0.0/8 are reserved for Source Specific Multicast (SSM) by IANA. In Cisco IOS software, you can use the `ip pim ssm` command to configure SSM for arbitrary IP multicast addresses also. SSM is an extension of Protocol Independent Multicast (PIM) that allows for an efficient data delivery mechanism in one-to-many communications. SSM is described in the [IP Multicast Delivery Modes, on page 437](#) section.

### GLOP Addresses

GLOP addressing (as proposed by RFC 2770, GLOP Addressing in 233/8) proposes that the 233.0.0.0/8 range be reserved for statically defined addresses by organizations that already have an AS number reserved. This practice is called GLOP addressing. The AS number of the domain is embedded into the second and third octets of the 233.0.0.0/8 address range. For example, AS 62010 is written in hexadecimal format as F23A. Separating the two octets F2 and 3A results in 242 and 58 in decimal format. These values result in a subnet of 233.242.58.0/24 that would be globally reserved for AS 62010 to use.

### Limited Scope Addresses

The range 239.0.0.0 to 239.255.255.255 is reserved as administratively or limited scoped addresses for use in private multicast domains. These addresses are constrained to a local group or organization. Companies, universities, and other organizations can use limited scope addresses to have local multicast applications that will not be forwarded outside their domain. Routers typically are configured with filters to prevent multicast traffic in this address range from flowing outside an autonomous system (AS) or any user-defined domain. Within an AS or domain, the limited scope address range can be further subdivided so that local multicast boundaries can be defined.



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**Note** Network administrators may use multicast addresses in this range, inside a domain, without conflicting with others elsewhere in the Internet.

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## Layer 2 Multicast Addresses

Historically, network interface cards (NICs) on a LAN segment could receive only packets destined for their burned-in MAC address or the broadcast MAC address. In IP multicast, several hosts need to be able to receive a single data stream with a common destination MAC address. Some means had to be devised so that multiple hosts could receive the same packet and still be able to differentiate between several multicast groups. One method to accomplish this is to map IP multicast Class D addresses directly to a MAC address. Using this method, NICs can receive packets destined to many different MAC address.

Cisco Group Management Protocol (CGMP) is used on routers connected to Catalyst switches to perform tasks similar to those performed by IGMP. CGMP is necessary for those Catalyst switches that cannot distinguish between IP multicast data packets and IGMP report messages, both of which are addressed to the same group address at the MAC level.

## IP Multicast Delivery Modes

IP multicast delivery modes differ only for the receiver hosts, not for the source hosts. A source host sends IP multicast packets with its own IP address as the IP source address of the packet and a group address as the IP destination address of the packet.

### Source Specific Multicast

Source Specific Multicast (SSM) is a datagram delivery model that best supports one-to-many applications, also known as broadcast applications. SSM is a core network technology for the Cisco implementation of IP multicast targeted for audio and video broadcast application environments.

For the SSM delivery mode, an IP multicast receiver host must use IGMP Version 3 (IGMPv3) to subscribe to channel (S,G). By subscribing to this channel, the receiver host is indicating that it wants to receive IP multicast traffic sent by source host S to group G. The network will deliver IP multicast packets from source host S to group G to all hosts in the network that have subscribed to the channel (S, G).

SSM does not require group address allocation within the network, only within each source host. Different applications running on the same source host must use different SSM groups. Different applications running on different source hosts can arbitrarily reuse SSM group addresses without causing any excess traffic on the network.





## CHAPTER 28

# Configuring IGMP

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- [Prerequisites for IGMP and IGMP Snooping](#), on page 439
- [Restrictions for IGMP and IGMP Snooping](#), on page 440
- [Information About IGMP](#), on page 441
- [How to Configure IGMP](#), on page 451
- [Monitoring IGMP](#), on page 488
- [Configuration Examples for IGMP](#), on page 490
- [Additional References](#), on page 496
- [Feature History and Information for IGMP](#), on page 497

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see [Bug Search Tool](#) and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

## Prerequisites for IGMP and IGMP Snooping

### Prerequisites for IGMP

- Before performing the tasks in this module, you should be familiar with the concepts explained in the "IP Multicast Routing Technology Overview" module.
- The tasks in this module assume that IP multicast has been enabled and that the Protocol Independent Multicast (PIM) interfaces have been configured using the tasks described in the "Configuring Basic IP Multicast Routing" module.

## Prerequisites for IGMP Snooping

Observe these guidelines when configuring the IGMP snooping querier:

- Configure the VLAN in global configuration mode.
- Configure an IP address on the VLAN interface. When enabled, the IGMP snooping querier uses the IP address as the query source address.
- If there is no IP address configured on the VLAN interface, the IGMP snooping querier tries to use the configured global IP address for the IGMP querier. If there is no global IP address specified, the IGMP querier tries to use the VLAN device virtual interface (SVI) IP address (if one exists). If there is no SVI IP address, the device uses the first available IP address configured on the device. The first IP address available appears in the output of the **show ip interface** privileged EXEC command. The IGMP snooping querier does not generate an IGMP general query if it cannot find an available IP address on the device.
- The IGMP snooping querier supports IGMP Versions 1 and 2.
- When administratively enabled, the IGMP snooping querier moves to the nonquerier state if it detects the presence of a multicast router in the network.
- When it is administratively enabled, the IGMP snooping querier moves to the operationally disabled state under these conditions:
  - IGMP snooping is disabled in the VLAN.
  - PIM is enabled on the SVI of the corresponding VLAN.
  - 
  -

## Restrictions for IGMP and IGMP Snooping

### Restrictions for Configuring IGMP

The following are the restrictions for configuring IGMP:

- The device supports IGMP Versions 1, 2, and 3.




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**Note** For IGMP Version 3, only IGMP Version 3 BISS (Basic IGMPv3 Snooping Support) is supported.

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- IGMP Version 3 uses new membership report messages that might not be correctly recognized by older IGMP snooping devices.
- IGMPv3 can operate with both ISM and SSM. In ISM, both exclude and include mode reports are applicable. In SSM, only include mode reports are accepted by the last-hop router. Exclude mode reports are ignored.
- IGMP filtering and throttling is not supported under the WLAN.

- You cannot have a device stack containing a mix of Catalyst 3850 and Catalyst 3650 devices.

## Restrictions for IGMP Snooping

The following are the restrictions for IGMP snooping:

- The device supports IGMPv3 snooping based only on the destination multicast IP address. It does not support snooping based on a source IP address or proxy report.
- IGMPv3 join and leave messages are not supported on devices running IGMP filtering or Multicast VLAN registration (MVR).
- IGMP report suppression is supported only when the multicast query has IGMPv1 and IGMPv2 reports. This feature is not supported when the query includes IGMPv3 reports.
- The IGMP configurable leave time is only supported on hosts running IGMP Version 2. IGMP version 2 is the default version for the device.

The actual leave latency in the network is usually the configured leave time. However, the leave time might vary around the configured time, depending on real-time CPU load conditions, network delays and the amount of traffic sent through the interface.

- The IGMP throttling action restriction can be applied only to Layer 2 ports. You can use **ip igmp max-groups action replace** interface configuration command on a logical EtherChannel interface but cannot use it on ports that belong to an EtherChannel port group.

When the maximum group limitation is set to the default (no maximum), entering the **ip igmp max-groups action {deny | replace}** command has no effect.

If you configure the throttling action and set the maximum group limitation after an interface has added multicast entries to the forwarding table, the forwarding-table entries are either aged out or removed, depending on the throttling action.

## Information About IGMP

### Role of the Internet Group Management Protocol

IGMP is used to dynamically register individual hosts in a multicast group on a particular LAN. Enabling PIM on an interface also enables IGMP. IGMP provides a means to automatically control and limit the flow of multicast traffic throughout your network with the use of special multicast queriers and hosts.

- A querier is a network device, such as a router, that sends query messages to discover which network devices are members of a given multicast group.
- A host is a receiver, including routers, that sends report messages (in response to query messages) to inform the querier of a host membership. Hosts use IGMP messages to join and leave multicast groups.

Hosts identify group memberships by sending IGMP messages to their local multicast device. Under IGMP, devices listen to IGMP messages and periodically send out queries to discover which groups are active or inactive on a particular subnet.

## IGMP Multicast Addresses

IP multicast traffic uses group addresses, which are Class D IP addresses. The high-order four bits of a Class D address are 1110. Therefore, host group addresses can be in the range 224.0.0.0 to 239.255.255.255.

Multicast addresses in the range 224.0.0.0 to 224.0.0.255 are reserved for use by routing protocols and other network control traffic. The address 224.0.0.0 is guaranteed not to be assigned to any group.

IGMP packets are transmitted using IP multicast group addresses as follows:

- IGMP general queries are destined to the address 224.0.0.1 (all systems on a subnet).
- IGMP group-specific queries are destined to the group IP address for which the device is querying.
- IGMP group membership reports are destined to the group IP address for which the device is reporting.
- IGMPv2 leave-group messages are destined to the address 224.0.0.2 (all devices on a subnet).
- IGMPv3 membership reports are destined to the address 224.0.0.22; all IGMPv3-capable multicast devices must listen to this address.

## IGMP Versions

The device supports IGMP version 1, IGMP version 2, and IGMP version 3. These versions are interoperable on the device. For example, if IGMP snooping is enabled and the querier's version is IGMPv2, and the device receives an IGMPv3 report from a host, then the device can forward the IGMPv3 report to the multicast router.

An IGMPv3 device can receive messages from and forward messages to a device running the Source Specific Multicast (SSM) feature.

### IGMP Version 1

IGMP version 1 (IGMPv1) primarily uses a query-response model that enables the multicast router and multilayer device to find which multicast groups are active (have one or more hosts interested in a multicast group) on the local subnet. IGMPv1 has other processes that enable a host to join and leave a multicast group. For more information, see RFC 1112.

### IGMP Version 2

IGMPv2 extends IGMP functionality by providing such features as the IGMP leave process to reduce leave latency, group-specific queries, and an explicit maximum query response time. IGMPv2 also adds the capability for routers to elect the IGMP querier without depending on the multicast protocol to perform this task. For more information, see RFC 2236.



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**Note** IGMP version 2 is the default version for the device.

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### IGMP Version 3

The device supports IGMP version 3.

An IGMPv3 device supports Basic IGMPv3 Snooping Support (BISS), which includes support for the snooping features on IGMPv1 and IGMPv2 switches and for IGMPv3 membership report messages. BISS constrains



the flooding of multicast traffic when your network includes IGMPv3 hosts. It constrains traffic to approximately the same set of ports as the IGMP snooping feature on IGMPv2 or IGMPv1 hosts.

An IGMPv3 device can receive messages from and forward messages to a device running the Source Specific Multicast (SSM) feature.

## IGMPv3 Host Signaling

IGMPv3 is the third version of the IETF standards track protocol in which hosts signal membership to last-hop devices of multicast groups. IGMPv3 introduces the ability for hosts to signal group membership that allows filtering capabilities with respect to sources. A host can signal either that it wants to receive traffic from all sources sending to a group except for some specific sources (a mode called EXCLUDE) or that it wants to receive traffic only from some specific sources sending to the group (a mode called INCLUDE).

IGMPv3 can operate with both ISM and SSM. In ISM, both EXCLUDE and INCLUDE mode reports are accepted by the last-hop router. In SSM, only INCLUDE mode reports are accepted by the last-hop router.

## IGMP Versions Differences

There are three versions of IGMP, as defined by Request for Comments (RFC) documents of the Internet Engineering Task Force (IETF). IGMPv2 improves over IGMPv1 by adding the ability for a host to signal desire to leave a multicast group and IGMPv3 improves over IGMPv2 mainly by adding the ability to listen to multicast originating from a set of source IP addresses only.

**Table 33: IGMP Versions**

IGMP Version	Description
IGMPv1	Provides the basic query-response mechanism that allows the multicast device to determine which multicast groups are active and other processes that enable hosts to join and leave a multicast group. RFC 1112 defines the IGMPv1 host extensions for IP multicasting.
IGMPv2	Extends IGMP, allowing such capabilities as the IGMP leave process, group-specific queries, and an explicit maximum response time field. IGMPv2 also adds the capability for devices to elect the IGMP querier without dependence on the multicast protocol to perform this task. RFC 2236 defines IGMPv2.



**Note** By default, enabling a PIM on an interface enables IGMPv2 on that device. IGMPv2 was designed to be as backward compatible with IGMPv1 as possible. To accomplish this backward compatibility, RFC 2236 defined special interoperability rules. If your network contains legacy IGMPv1 hosts, you should be familiar with these operability rules. For more information about IGMPv1 and IGMPv2 interoperability, see RFC 2236, Internet Group Management Protocol, Version 2 .

### Devices That Run IGMPv1

IGMPv1 devices send IGMP queries to the “all-hosts” multicast address of 224.0.0.1 to solicit multicast groups with active multicast receivers. The multicast receivers also can send IGMP reports to the device to notify it that they are interested in receiving a particular multicast stream. Hosts can send the report

asynchronously or in response to the IGMP queries sent by the device. If more than one multicast receiver exists for the same multicast group, only one of these hosts sends an IGMP report message; the other hosts suppress their report messages.

In IGMPv1, there is no election of an IGMP querier. If more than one device on the segment exists, all the devices send periodic IGMP queries. IGMPv1 has no special mechanism by which the hosts can leave the group. If the hosts are no longer interested in receiving multicast packets for a particular group, they simply do not reply to the IGMP query packets sent from the device. The device continues sending query packets. If the device does not hear a response in three IGMP queries, the group times out and the device stops sending multicast packets on the segment for the group. If the host later wants to receive multicast packets after the timeout period, the host simply sends a new IGMP join to the device, and the device begins to forward the multicast packet again.

If there are multiple devices on a LAN, a designated router (DR) must be elected to avoid duplicating multicast traffic for connected hosts. PIM devices follow an election process to select a DR. The PIM device with the highest IP address becomes the DR.

The DR is responsible for the following tasks:

- Sending PIM register and PIM Join and Prune messages toward the rendezvous point (RP) to inform it about host group membership.
- Sending IGMP host-query messages.
- Sending host-query messages by default every 60 seconds in order to keep the IGMP overhead on hosts and networks very low.

### Devices That Run IGMPv2

IGMPv2 improves the query messaging capabilities of IGMPv1.

The query and membership report messages in IGMPv2 are identical to the IGMPv1 messages with two exceptions:

- IGMPv2 query messages are broken into two categories: general queries (identical to IGMPv1 queries) and group-specific queries.
- IGMPv1 membership reports and IGMPv2 membership reports have different IGMP type codes.

IGMPv2 also enhances IGMP by providing support for the following capabilities:

- Querier election process--Provides the capability for IGMPv2 devices to elect the IGMP querier without having to rely on the multicast routing protocol to perform the process.
- Maximum Response Time field--A new field in query messages permits the IGMP querier to specify the maximum query-response time. This field permits the tuning of the query-response process to control response burstiness and to fine-tune leave latencies.
- Group-Specific Query messages--Permits the IGMP querier to perform the query operation on a specific group instead of all groups.
- Leave-Group messages--Provides hosts with a method of notifying devices on the network that they wish to leave the group.

Unlike IGMPv1, in which the DR and the IGMP querier are typically the same device, in IGMPv2 the two functions are decoupled. The DR and the IGMP querier are selected based on different criteria and may be

different devices on the same subnet. The DR is the device with the highest IP address on the subnet, whereas the IGMP querier is the device with the lowest IP address.

Query messages are used to elect the IGMP querier as follows:

1. When IGMPv2 devices start, they each multicast a general query message to the all-systems group address of 224.0.0.1 with their interface address in the source IP address field of the message.
2. When an IGMPv2 device receives a general query message, the device compares the source IP address in the message with its own interface address. The device with the lowest IP address on the subnet is elected the IGMP querier.
3. All devices (excluding the querier) start the query timer, which is reset whenever a general query message is received from the IGMP querier. If the query timer expires, it is assumed that the IGMP querier has gone down, and the election process is performed again to elect a new IGMP querier.

By default, the timer is two times the query interval.

## IGMP Join and Leave Process

### IGMP Join Process

When a host wants to join a multicast group, the host sends one or more unsolicited membership reports for the multicast group it wants to join. The IGMP join process is the same for IGMPv1 and IGMPv2 hosts.

In IGMPv3, the join process for hosts proceeds as follows:

- When a host wants to join a group, it sends an IGMPv3 membership report to 224.0.0.22 with an empty EXCLUDE list.
- When a host wants to join a specific channel, it sends an IGMPv3 membership report to 224.0.0.22 with the address of the specific source included in the INCLUDE list.
- When a host wants to join a group excluding particular sources, it sends an IGMPv3 membership report to 224.0.0.22 excluding those sources in the EXCLUDE list.



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**Note** If some IGMPv3 hosts on a LAN wish to exclude a source and others wish to include the source, then the device will send traffic for the source on the LAN (that is, inclusion trumps exclusion in this situation).

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### IGMP Leave Process

The method that hosts use to leave a group varies depending on the version of IGMP in operation.

#### IGMPv1 Leave Process

There is no leave-group message in IGMPv1 to notify the devices on the subnet that a host no longer wants to receive the multicast traffic from a specific group. The host simply stops processing traffic for the multicast group and ceases responding to IGMP queries with IGMP membership reports for the group. As a result, the only way IGMPv1 devices know that there are no longer any active receivers for a particular multicast group on a subnet is when the devices stop receiving membership reports. To facilitate this process, IGMPv1 devices associate a countdown timer with an IGMP group on a subnet. When a membership report is received for the

group on the subnet, the timer is reset. For IGMPv1 devices, this timeout interval is typically three times the query interval (3 minutes). This timeout interval means that the device may continue to forward multicast traffic onto the subnet for up to 3 minutes after all hosts have left the multicast group.

### IGMPv2 Leave Process

IGMPv2 incorporates a leave-group message that provides the means for a host to indicate that it wishes to stop receiving multicast traffic for a specific group. When an IGMPv2 host leaves a multicast group, if it was the last host to respond to a query with a membership report for that group, it sends a leave-group message to the all-devices multicast group (224.0.0.2).

### IGMPv3 Leave Process

IGMPv3 enhances the leave process by introducing the capability for a host to stop receiving traffic from a particular group, source, or channel in IGMP by including or excluding sources, groups, or channels in IGMPv3 membership reports.

## IGMP Snooping

Layer 2 devices can use IGMP snooping to constrain the flooding of multicast traffic by dynamically configuring Layer 2 interfaces so that multicast traffic is forwarded to only those interfaces associated with IP multicast devices. As the name implies, IGMP snooping requires the LAN device to snoop on the IGMP transmissions between the host and the router and to keep track of multicast groups and member ports. When the device receives an IGMP report from a host for a particular multicast group, the device adds the host port number to the forwarding table entry; when it receives an IGMP Leave Group message from a host, it removes the host port from the table entry. It also periodically deletes entries if it does not receive IGMP membership reports from the multicast clients.



#### Note

For more information on IP multicast and IGMP, see RFC 1112 and RFC 2236.

The multicast router (which could be a device with the IP services feature) set on the active device sends out periodic general queries to all VLANs. All hosts interested in this multicast traffic send join requests and are added to the forwarding table entry. The device creates one entry per VLAN in the IGMP snooping IP multicast forwarding table for each group from which it receives an IGMP join request.

The device supports IP multicast group-based bridging, instead of MAC-addressed based groups. With multicast MAC address-based groups, if an IP address being configured translates (aliases) to a previously configured MAC address or to any reserved multicast MAC addresses (in the range 224.0.0.xxx), the command fails. Because the device uses IP multicast groups, there are no address aliasing issues.

The IP multicast groups learned through IGMP snooping are dynamic. However, you can statically configure multicast groups by using the **ip igmp snooping vlan *vlan-id* static *ip\_address* interface *interface-id*** global configuration command. If you specify group membership for a multicast group address statically, your setting supersedes any automatic manipulation by IGMP snooping. Multicast group membership lists can consist of both user-defined and IGMP snooping-learned settings.

You can configure an IGMP snooping querier to support IGMP snooping in subnets without multicast interfaces because the multicast traffic does not need to be routed.

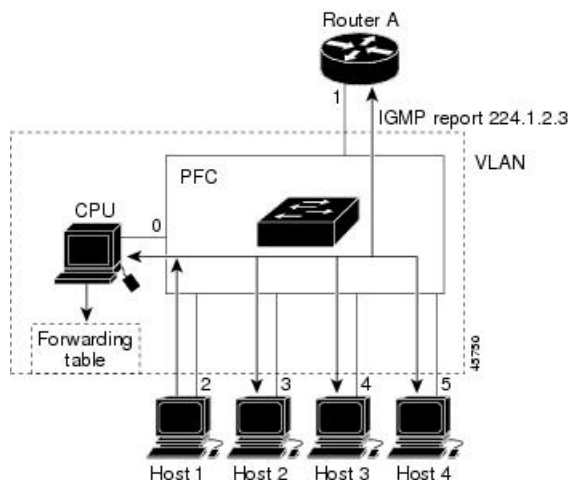
If a port spanning-tree, a port group, or a VLAN ID change occurs, the IGMP snooping-learned multicast groups from this port on the VLAN are deleted.

These sections describe IGMP snooping characteristics:

## Joining a Multicast Group

**Figure 23: Initial IGMP Join Message**

When a host connected to the device wants to join an IP multicast group and it is an IGMP version 2 client, it sends an unsolicited IGMP join message, specifying the IP multicast group to join. Alternatively, when the device receives a general query from the router, it forwards the query to all ports in the VLAN. IGMP version 1 or version 2 hosts wanting to join the multicast group respond by sending a join message to the device. The device CPU creates a multicast forwarding-table entry for the group if it is not already present. The CPU also adds the interface where the join message was received to the forwarding-table entry. The host associated with that interface receives multicast traffic for that multicast group.



Router A sends a general query to the device, which forwards the query to ports 2 through 5, all of which are members of the same VLAN. Host 1 wants to join multicast group 224.1.2.3 and multicasts an IGMP membership report (IGMP join message) to the group. The device CPU uses the information in the IGMP report to set up a forwarding-table entry that includes the port numbers connected to Host 1 and to the router.

**Table 34: IGMP Snooping Forwarding Table**

Destination Address	Type of Packet	Ports
224.1.2.3	IGMP	1, 2

The device hardware can distinguish IGMP information packets from other packets for the multicast group. The information in the table tells the switching engine to send frames addressed to the 224.1.2.3 multicast IP address that are not IGMP packets to the router and to the host that has joined the group.

**Figure 24: Second Host Joining a Multicast Group**

If another host (for example, Host 4) sends an unsolicited IGMP join message for the same group, the CPU receives that message and adds the port number of Host 4 to the forwarding table. Because the forwarding table directs IGMP messages only to the CPU, the message is not flooded to other ports on the device. Any

known multicast traffic is forwarded to the group and not to the CPU.

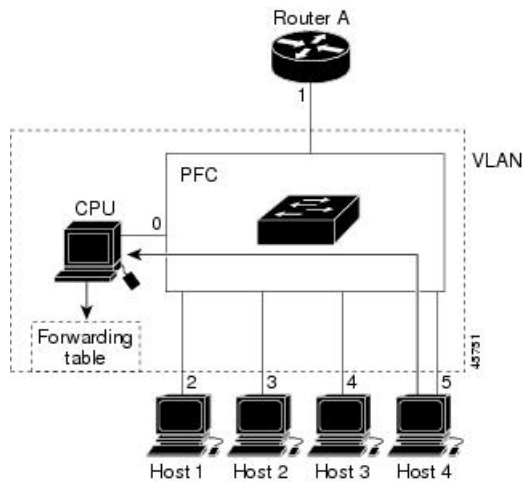


Table 35: Updated IGMP Snooping Forwarding Table

Destination Address	Type of Packet	Ports
224.1.2.3	IGMP	1, 2, 5

## Leaving a Multicast Group

The router sends periodic multicast general queries, and the device forwards these queries through all ports in the VLAN. Interested hosts respond to the queries. If at least one host in the VLAN wants to receive multicast traffic, the router continues forwarding the multicast traffic to the VLAN. The device forwards multicast group traffic only to those hosts listed in the forwarding table for that IP multicast group maintained by IGMP snooping.

When hosts want to leave a multicast group, they can silently leave, or they can send a leave message. When the device receives a leave message from a host, it sends a group-specific query to learn if any other devices connected to that interface are interested in traffic for the specific multicast group. The device then updates the forwarding table for that MAC group so that only those hosts interested in receiving multicast traffic for the group are listed in the forwarding table. If the router receives no reports from a VLAN, it removes the group for the VLAN from its IGMP cache.

## Immediate Leave

The device uses IGMP snooping Immediate Leave to remove from the forwarding table an interface that sends a leave message without the device sending group-specific queries to the interface. The VLAN interface is pruned from the multicast tree for the multicast group specified in the original leave message. Immediate Leave ensures optimal bandwidth management for all hosts on a switched network, even when multiple multicast groups are simultaneously in use.

Immediate Leave is only supported on IGMP version 2 hosts. IGMP version 2 is the default version for the device.



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**Note** You should use the Immediate Leave feature only on VLANs where a single host is connected to each port. If Immediate Leave is enabled on VLANs where more than one host is connected to a port, some hosts may be dropped inadvertently.

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## IGMP Configurable-Leave Timer

You can configure the time that the device waits after sending a group-specific query to determine if hosts are still interested in a specific multicast group. The IGMP leave response time can be configured from 100 to 32767 milliseconds.

## IGMP Report Suppression



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**Note** IGMP report suppression is supported only when the multicast query has IGMPv1 and IGMPv2 reports. This feature is not supported when the query includes IGMPv3 reports.

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The device uses IGMP report suppression to forward only one IGMP report per multicast router query to multicast devices. When IGMP report suppression is enabled (the default), the device sends the first IGMP report from all hosts for a group to all the multicast routers. The device does not send the remaining IGMP reports for the group to the multicast routers. This feature prevents duplicate reports from being sent to the multicast devices.

If the multicast router query includes requests only for IGMPv1 and IGMPv2 reports, the device forwards only the first IGMPv1 or IGMPv2 report from all hosts for a group to all the multicast routers.

If the multicast router query also includes requests for IGMPv3 reports, the device forwards all IGMPv1, IGMPv2, and IGMPv3 reports for a group to the multicast devices.

If you disable IGMP report suppression, all IGMP reports are forwarded to the multicast routers.

## IGMP Snooping and Device Stacks

IGMP snooping functions across the device stack; that is, IGMP control information from one device is distributed to all devices in the stack. Regardless of the stack member through which IGMP multicast data enters the stack, the data reaches the hosts that have registered for that group.

If a device in the stack fails or is removed from the stack, only the members of the multicast group that are on that device will not receive the multicast data. All other members of a multicast group on other devices in the stack continue to receive multicast data streams. However, multicast groups that are common for both Layer 2 and Layer 3 (IP multicast routing) might take longer to converge if the active device is removed.

## IGMP Filtering and Throttling

In some environments, for example, metropolitan or multiple-dwelling unit (MDU) installations, you might want to control the set of multicast groups to which a user on a device port can belong. You can control the distribution of multicast services, such as IP/TV, based on some type of subscription or service plan. You might also want to limit the number of multicast groups to which a user on a device port can belong.

With the IGMP filtering feature, you can filter multicast joins on a per-port basis by configuring IP multicast profiles and associating them with individual device ports. An IGMP profile can contain one or more multicast

groups and specifies whether access to the group is permitted or denied. If an IGMP profile denying access to a multicast group is applied to a device port, the IGMP join report requesting the stream of IP multicast traffic is dropped, and the port is not allowed to receive IP multicast traffic from that group. If the filtering action permits access to the multicast group, the IGMP report from the port is forwarded for normal processing. You can also set the maximum number of IGMP groups that a Layer 2 interface can join.

IGMP filtering controls only group-specific query and membership reports, including join and leave reports. It does not control general IGMP queries. IGMP filtering has no relationship with the function that directs the forwarding of IP multicast traffic. The filtering feature operates in the same manner whether CGMP or MVR is used to forward the multicast traffic.

IGMP filtering applies only to the dynamic learning of IP multicast group addresses, not static configuration.

With the IGMP throttling feature, you can set the maximum number of IGMP groups that a Layer 2 interface can join. If the maximum number of IGMP groups is set, the IGMP snooping forwarding table contains the maximum number of entries, and the interface receives an IGMP join report, you can configure an interface to drop the IGMP report or to replace the randomly selected multicast entry with the received IGMP report.



**Note** IGMPv3 join and leave messages are not supported on devices running IGMP filtering.

## Default IGMP Configuration

This table displays the default IGMP configuration for the device.

**Table 36: Default IGMP Configuration**

Feature	Default Setting
Multilayer device as a member of a multicast group	No group memberships are defined.
Access to multicast groups	All groups are allowed on an interface.
IGMP version	Version 2 on all interfaces.
IGMP host-query message interval	60 seconds on all interfaces.
IGMP query timeout	60 seconds on all interfaces.
IGMP maximum query response time	10 seconds on all interfaces.
Multilayer device as a statically connected member	Disabled.

## Default IGMP Snooping Configuration

This table displays the default IGMP snooping configuration for the device.

**Table 37: Default IGMP Snooping Configuration**

Feature	Default Setting
IGMP snooping	Enabled globally and per VLAN



Feature	Default Setting
Multicast routers	None configured
IGMP snooping Immediate Leave	Disabled
Static groups	None configured
TCN <sup>1</sup> flood query count	2
TCN query solicitation	Disabled
IGMP snooping querier	Disabled
IGMP report suppression	Enabled

<sup>1</sup> (1) TCN = Topology Change Notification

## Default IGMP Filtering and Throttling Configuration

This table displays the default IGMP filtering and throttling configuration for the device.

**Table 38: Default IGMP Filtering Configuration**

Feature	Default Setting
IGMP filters	None applied.
IGMP maximum number of IGMP groups	No maximum set.  <b>Note</b> When the maximum number of groups is in the forwarding table, the default IGMP throttling action is to deny the IGMP report.
IGMP profiles	None defined.
IGMP profile action	Deny the range addresses.

## How to Configure IGMP

### Configuring the Device as a Member of a Group (CLI)

You can configure the device as a member of a multicast group and discover multicast reachability in a network. If all the multicast-capable routers and multilayer devices that you administer are members of a multicast group, pinging that group causes all of these devices to respond. The devices respond to ICMP echo-request packets addressed to a group of which they are members. Another example is the multicast trace-route tools provided in the software.



**Caution** Performing this procedure might impact the CPU performance because the CPU will receive all data traffic for the group address.

This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface</b> <b>gigabitethernet 1/0/1</b>	Specifies the Layer 3 interface on which you want to enable multicast routing, and enters interface configuration mode.  The specified interface must be one of the following: <ul style="list-style-type: none"> <li>• A routed port—A physical port that has been configured as a Layer 3 port by entering the <b>no switchport</b> interface configuration command.</li> <li>• An SVI—A VLAN interface created by using the <b>interface vlan <i>vlan-id</i></b> global configuration command.</li> </ul> These interfaces must have IP addresses assigned to them.
<b>Step 4</b>	<b>ip igmp join-group <i>group-address</i></b> <b>Example:</b> Device(config-if)# <b>ip igmp</b> <b>join-group 225.2.2.2</b>	Configures the device to join a multicast group.  By default, no group memberships are defined.  For <i>group-address</i> , specify the multicast IP address in dotted decimal notation.
<b>Step 5</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	Device(config)# <b>end</b>	
<b>Step 6</b>	<b>show ip igmp interface</b> [ <i>interface-id</i> ] <b>Example:</b> Device# <b>show ip igmp interface</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Controlling Access to IP Multicast Group (CLI)

The device sends IGMP host-query messages to find which multicast groups have members on attached local networks. The device then forwards to these group members all packets addressed to the multicast group. You can place a filter on each interface to restrict the multicast groups that hosts on the subnet serviced by the interface can join.

To limit the number of joins on the interface, configure the port for the filter which associates with the IGMP profile.

This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip igmp profile</b> <b>Example:</b> Device(config)# <b>ip igmp profile 10</b> Device(config-igmp-profile)# <b>?</b>	Enters an IGMP filter profile number from 1 to 4294967295.  For additional information about configuring IGMP filter profiles, see <a href="#">Configuring IGMP Profiles (CLI)</a> , on page 462.

	Command or Action	Purpose
<b>Step 4</b>	<b>permit</b> <b>Example:</b> <pre>Device (config-igmp-profile) # permit 229.9.9.0</pre>	Enters an IGMP profile configuration action. The following IGMP profile configuration actions are supported: <ul style="list-style-type: none"> <li>• <b>deny</b>—Matching IP addresses are denied.</li> <li>• <b>exit</b>—Exits from the IGMP profile configuration mode.</li> <li>• <b>no</b>—Negates a command or set its defaults.</li> <li>• <b>permit</b>—Matching addresses are permitted.</li> <li>• <b>range</b>—Adds a range to the set.</li> </ul>
<b>Step 5</b>	<b>exit</b> <b>Example:</b> <pre>Device (config-igmp-profile) # exit</pre>	Returns to global configuration mode.
<b>Step 6</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> <pre>Device (config) # interface gigabitethernet 1/0/1</pre>	Specifies the interface to be configured, and enters interface configuration mode.
<b>Step 7</b>	<b>ip igmp filter <i>filter_number</i></b> <b>Example:</b> <pre>Device (config-if) # ip igmp filter 10</pre>	Specifies the IGMP filter profile number. For additional information about applying IGMP filter profiles, see <a href="#">Applying IGMP Profiles (CLI)</a> , on page 464.
<b>Step 8</b>	<b>end</b> <b>Example:</b> <pre>Device (config) # end</pre>	Returns to privileged EXEC mode.
<b>Step 9</b>	<b>show ip igmp interface [<i>interface-id</i>]</b> <b>Example:</b> <pre>Device# show ip igmp interface</pre>	Verifies your entries.
<b>Step 10</b>	<b>copy running-config startup-config</b> <b>Example:</b>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Device# <code>copy running-config startup-config</code>	

## Changing the IGMP Version(CLI)

By default, the switch uses IGMP Version 2, which provides features such as the IGMP query timeout and the maximum query response time.

All systems on the subnet must support the same version. The switch does not automatically detect Version 1 systems and switch to Version 1. You can mix Version 1 and Version 2 hosts on the subnet because Version 2 routers or switches always work correctly with IGMPv1 hosts.

Configure the switch for Version 1 if your hosts do not support Version 2.

This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <code>interface gigabitethernet 1/0/1</code>	Specifies the interface to be configured, and enters the interface configuration mode.
<b>Step 4</b>	<b>ip igmp version {1   2   3 }</b> <b>Example:</b> Device(config-if)# <code>ip igmp version 2</code>	Specifies the IGMP version that the switch uses. <p><b>Note</b> If you change to Version 1, you cannot configure the <b>ip igmp query-interval</b> or the <b>ip igmp query-max-response-time</b> interface configuration commands.</p> <p>To return to the default setting, use the <b>no ip igmp version</b> interface configuration command.</p>

	Command or Action	Purpose
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show ip igmp interface</b> [ <i>interface-id</i> ] <b>Example:</b> Device# <b>show ip igmp interface</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Modifying the IGMP Host-Query Message Interval (CLI)

The device periodically sends IGMP host-query messages to discover which multicast groups are present on attached networks. These messages are sent to the all-hosts multicast group (224.0.0.1) with a time-to-live (TTL) of 1. The device sends host-query messages to refresh its knowledge of memberships present on the network. If, after some number of queries, the software discovers that no local hosts are members of a multicast group, the software stops forwarding multicast packets to the local network from remote origins for that group and sends a prune message upstream toward the source.

The device elects a PIM designated router (DR) for the LAN (subnet). The designated router is responsible for sending IGMP host-query messages to all hosts on the LAN. In sparse mode, the designated router also sends PIM register and PIM join messages toward the RP router. With IGMPv2, the DR is the router or multilayer device with the highest IP address. With IGMPv1, the DR is elected according to the multicast routing protocol that runs on the LAN.

This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 3</b>	<p><code>interface interface-id</code></p> <p><b>Example:</b></p> <pre>Device(config)# interface gigabitethernet 1/0/1</pre>	<p>Specifies the Layer 3 interface on which you want to enable multicast routing, and enters interface configuration mode.</p> <p>The specified interface must be one of the following:</p> <ul style="list-style-type: none"> <li>• A routed port—A physical port that has been configured as a Layer 3 port by entering the <b>no switchport</b> interface configuration command.</li> <li>• An SVI—A VLAN interface created by using the <b>interface vlan vlan-id</b> global configuration command.</li> </ul> <p>These interfaces must have IP addresses assigned to them.</p>
<b>Step 4</b>	<p><code>ip igmp query-interval seconds</code></p> <p><b>Example:</b></p> <pre>Device(config-if)# ip igmp query-interval 75</pre>	<p>Configures the frequency at which the designated router sends IGMP host-query messages.</p> <p>By default, the designated router sends IGMP host-query messages every 60 seconds to keep the IGMP overhead very low on hosts and networks.</p> <p>The range is 1 to 65535.</p>
<b>Step 5</b>	<p><code>end</code></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<p><code>show ip igmp interface [interface-id]</code></p> <p><b>Example:</b></p> <pre>Device# show ip igmp interface</pre>	Verifies your entries.
<b>Step 7</b>	<p><code>copy running-config startup-config</code></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Changing the IGMP Query Timeout for IGMPv2 (CLI)

If you are using IGMPv2, you can specify the period of time before the device takes over as the querier for the interface. By default, the device waits twice the query interval period controlled by the **ip igmp query-interval** interface configuration command. After that time, if the device has received no queries, it becomes the querier.

This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> Device(config)# <b>interface</b> <b>gigabitethernet 1/0/1</b>	Specifies the Layer 3 interface on which you want to enable multicast routing, and enters interface configuration mode.  The specified interface must be one of the following: <ul style="list-style-type: none"> <li>• A routed port—A physical port that has been configured as a Layer 3 port by entering the <b>no switchport</b> interface configuration command.</li> <li>• An SVI—A VLAN interface created by using the <b>interface vlan</b> <i>vlan-id</i> global configuration command.</li> </ul> These interfaces must have IP addresses assigned to them.
<b>Step 4</b>	<b>ip igmp querier-timeout</b> <i>seconds</i> <b>Example:</b> Device(config-if)# <b>ip igmp</b> <b>querier-timeout 120</b>	Specifies the IGMP query timeout.  The default is 60 seconds (twice the query interval). The range is 60 to 300.
<b>Step 5</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.



	Command or Action	Purpose
	Device(config)# <b>end</b>	
<b>Step 6</b>	<b>show ip igmp interface</b> [ <i>interface-id</i> ] <b>Example:</b> Device# <b>show ip igmp interface</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Changing the Maximum Query Response Time for IGMPv2 (CLI)

If you are using IGMPv2, you can change the maximum query response time advertised in IGMP queries. The maximum query response time enables the device to quickly detect that there are no more directly connected group members on a LAN. Decreasing the value enables the device to prune groups faster.

This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/1</b>	Specifies the Layer 3 interface on which you want to enable multicast routing, and enters interface configuration mode.  The specified interface must be one of the following: <ul style="list-style-type: none"> <li>• A routed port—A physical port that has been configured as a Layer 3 port by</li> </ul>

	Command or Action	Purpose
		<p>entering the <b>no switchport</b> interface configuration command.</p> <ul style="list-style-type: none"> <li>An SVI—A VLAN interface created by using the <b>interface vlan</b> <i>vlan-id</i> global configuration command.</li> </ul> <p>These interfaces must have IP addresses assigned to them.</p>
<b>Step 4</b>	<p><b>ip igmp query-max-response-time</b> <i>seconds</i></p> <p><b>Example:</b></p> <pre>Device(config-if)# ip igmp query-max-response-time 15</pre>	<p>Changes the maximum query response time advertised in IGMP queries.</p> <p>The default is 10 seconds. The range is 1 to 25.</p>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	<p>Returns to privileged EXEC mode.</p>
<b>Step 6</b>	<p><b>show ip igmp interface</b> [<i>interface-id</i>]</p> <p><b>Example:</b></p> <pre>Device# show ip igmp interface</pre>	<p>Verifies your entries.</p>
<b>Step 7</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	<p>(Optional) Saves your entries in the configuration file.</p>

## Configuring the Device as a Statically Connected Member (CLI)

At various times, either there is not a group member on a network segment or a host that cannot report its group membership by using IGMP. However, you may want multicast traffic to be sent to that network segment. The following commands are used to pull multicast traffic down to a network segment:

- **ip igmp join-group**—The device accepts the multicast packets in addition to forwarding them. Accepting the multicast packets prevents the device from fast switching.
- **ip igmp static-group**—The device does not accept the packets itself, but only forwards them. This method enables fast switching. The outgoing interface appears in the IGMP cache, but the device itself is not a member, as evidenced by lack of an L (local) flag in the multicast route entry.

This procedure is optional.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> <pre>Device(config)# interface gigabitethernet 1/0/1</pre>	Specifies the Layer 3 interface on which you want to enable multicast routing, and enters interface configuration mode.  The specified interface must be one of the following: <ul style="list-style-type: none"> <li>• A routed port—A physical port that has been configured as a Layer 3 port by entering the <b>no switchport</b> interface configuration command.</li> <li>• An SVI—A VLAN interface created by using the <b>interface vlan <i>vlan-id</i></b> global configuration command.</li> </ul> These interfaces must have IP addresses assigned to them.
<b>Step 4</b>	<b>ip igmp static-group <i>group-address</i></b> <b>Example:</b> <pre>Device(config-if)# ip igmp static-group 239.100.100.101</pre>	Configures the device as a statically connected member of a group.  By default, this feature is disabled.
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show ip igmp interface [<i>interface-id</i>]</b> <b>Example:</b> <pre>Device# show ip igmp interface</pre>	Verifies your entries.

	Command or Action	Purpose
	<code>gigabitethernet 1/0/1</code>	
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring IGMP Profiles (CLI)

Follow these steps to create an IGMP profile:

This task is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ip igmp profile <i>profile number</i></b> <b>Example:</b> <pre>Device(config)# ip igmp profile 3</pre>	Assigns a number to the profile you are configuring, and enters IGMP profile configuration mode. The profile number range is 1 to 4294967295. When you are in IGMP profile configuration mode, you can create the profile by using these commands: <ul style="list-style-type: none"> <li>• <b>deny</b>—Specifies that matching addresses are denied; this is the default.</li> <li>• <b>exit</b>—Exits from <code>igmp-profile</code> configuration mode.</li> <li>• <b>no</b>—Negates a command or returns to its defaults.</li> <li>• <b>permit</b>—Specifies that matching addresses are permitted.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li><b>range</b>—Specifies a range of IP addresses for the profile. You can enter a single IP address or a range with a start and an end address.</li> </ul> <p>The default is for the device to have no IGMP profiles configured.</p> <p><b>Note</b> To delete a profile, use the <b>no ip igmp profile <i>profile number</i></b> global configuration command.</p>
<b>Step 4</b>	<b>permit   deny</b> <b>Example:</b> Device(config-igmp-profile)# <b>permit</b>	(Optional) Sets the action to permit or deny access to the IP multicast address. If no action is configured, the default for the profile is to deny access.
<b>Step 5</b>	<b>range <i>ip multicast address</i></b> <b>Example:</b> Device(config-igmp-profile)# <b>range 229.9.9.0</b>	Enters the IP multicast address or range of IP multicast addresses to which access is being controlled. If entering a range, enter the low IP multicast address, a space, and the high IP multicast address.  You can use the <b>range</b> command multiple times to enter multiple addresses or ranges of addresses.  <p><b>Note</b> To delete an IP multicast address or range of IP multicast addresses, use the <b>no range <i>ip multicast address</i></b> IGMP profile configuration command.</p>
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show ip igmp profile <i>profile number</i></b> <b>Example:</b> Device# <b>show ip igmp profile 3</b>	Verifies the profile configuration.
<b>Step 8</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.

	Command or Action	Purpose
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Applying IGMP Profiles (CLI)

To control access as defined in an IGMP profile, you have to apply the profile to the appropriate interfaces. You can apply IGMP profiles only to Layer 2 access ports; you cannot apply IGMP profiles to routed ports or SVIs. You cannot apply profiles to ports that belong to an EtherChannel port group. You can apply a profile to multiple interfaces, but each interface can have only one profile applied to it.

Follow these steps to apply an IGMP profile to a switch port:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> <pre>Device(config)# interface gigabitethernet1/0/1</pre>	Specifies the physical interface, and enters interface configuration mode. The interface must be a Layer 2 port that does not belong to an EtherChannel port group.
<b>Step 4</b>	<b>ip igmp filter <i>profile number</i></b> <b>Example:</b> <pre>Device(config-if)# ip igmp filter 321</pre>	Applies the specified IGMP profile to the interface. The range is 1 to 4294967295. <p><b>Note</b> To remove a profile from an interface, use the <b>no ip igmp filter <i>profile number</i></b> interface configuration command.</p>
<b>Step 5</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	<code>Device(config-if)# end</code>	
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> <code>Device# show running-config</code>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> <code>Device# copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Setting the Maximum Number of IGMP Groups (CLI)

Follow these steps to set the maximum number of IGMP groups that a Layer 2 interface can join:

### Before you begin

This restriction can be applied to Layer 2 ports only; you cannot set a maximum number of IGMP groups on routed ports or SVIs. You also can use this command on a logical EtherChannel interface but cannot use it on ports that belong to an EtherChannel port group.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <code>Device&gt; enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <code>Device# configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> <code>Device(config)# interface gigabitethernet1/0/2</code>	Specifies the interface to be configured, and enters interface configuration mode. The interface can be a Layer 2 port that does not belong to an EtherChannel group or a EtherChannel interface.

	Command or Action	Purpose
<b>Step 4</b>	<b>ip igmp max-groups</b> <i>number</i> <b>Example:</b> Device(config-if)# <b>ip igmp max-groups</b> 20	Sets the maximum number of IGMP groups that the interface can join. The range is 0 to 4294967294. The default is to have no maximum set. <b>Note</b> The device supports a maximum number of 4096 Layer 2 IGMP groups and 2048 Layer 3 IGMP groups.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config interface</b> <i>interface-id</i> <b>Example:</b> Device# <b>interface</b> gigabitethernet1/0/1	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring the IGMP Throttling Action (CLI)

After you set the maximum number of IGMP groups that a Layer 2 interface can join, you can configure an interface to replace the existing group with the new group for which the IGMP report was received.

Follow these steps to configure the throttling action when the maximum number of entries is in the forwarding table:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.



	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 3</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> Device(config)# <b>interface</b> <b>gigabitethernet1/0/1</b>	Specifies the physical interface to be configured, and enters interface configuration mode. The interface can be a Layer 2 port that does not belong to an EtherChannel group or an EtherChannel interface. The interface cannot be a trunk port.
<b>Step 4</b>	<b>ip igmp max-groups action</b> {deny   replace} <b>Example:</b> Device(config-if)# <b>ip igmp max-groups</b> <b>action replace</b>	<p>When an interface receives an IGMP report and the maximum number of entries is in the forwarding table, specifies the action that the interface takes:</p> <ul style="list-style-type: none"> <li>• <b>deny</b>—Drops the report. If you configure this throttling action, the entries that were previously in the forwarding table are not removed but are aged out. After these entries are aged out and the maximum number of entries is in the forwarding table, the device drops the next IGMP report received on the interface.</li> <li>• <b>replace</b>—Replaces the existing group with the new group for which the IGMP report was received. If you configure this throttling action, the entries that were previously in the forwarding table are removed. When the maximum number of entries is in the forwarding table, the device replaces a randomly selected entry with the received IGMP report.</li> </ul> <p>To prevent the device from removing the forwarding-table entries, you can configure the IGMP throttling action before an interface adds entries to the forwarding table.</p> <p><b>Note</b> To return to the default action of dropping the report, use the <b>no ip igmp max-groups action</b> interface configuration command.</p>
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 6</b>	<b>show running-config interface <i>interface-id</i></b> <b>Example:</b> <pre>Device# show running-config interface gigabitethernet1/0/1</pre>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring the Device to Forward Multicast Traffic in the Absence of Directly Connected IGMP Hosts

Perform this optional task to configure the device to forward multicast traffic in the absence of directly connected IGMP hosts.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>type number</i></b> <b>Example:</b> <pre>device(config)# interface gigabitethernet 1</pre>	Enters interface configuration mode. <ul style="list-style-type: none"> <li>• For the <i>type</i> and <i>number</i> arguments, specify an interface that is connected to hosts.</li> </ul>
<b>Step 4</b>	Do one of the following: <ul style="list-style-type: none"> <li>• <b>ip igmp join-group <i>group-address</i></b></li> <li>• <b>ip igmp static-group <i>{*   group-address [source source-address]}</i></b></li> </ul> <b>Example:</b>	The first sample shows how to configure an interface on the device to join the specified group. With this method, the device accepts the multicast packets in addition to forwarding them. Accepting the multicast packets prevents the device from fast switching.

	Command or Action	Purpose
	<pre>device(config-if)# ip igmp join-group 225.2.2.2</pre> <p><b>Example:</b></p> <pre>device(config-if)# ip igmp static-group 225.2.2.2</pre>	The second example shows how to configure static group membership entries on an interface. With this method, the device does not accept the packets itself, but only forwards them. Hence, this method allows fast switching. The outgoing interface appears in the IGMP cache, but the device itself is not a member, as evidenced by lack of an “L” (local) flag in the multicast route entry
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>device#(config-if)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<p><b>show ip igmp interface</b> [<i>interface-type interface-number</i>]</p> <p><b>Example:</b></p> <pre>device# show ip igmp interface</pre>	(Optional) Displays multicast-related information about an interface.

## Controlling Access to an SSM Network Using IGMP Extended Access Lists

Perform this optional task to control access to an SSM network by using an IGMP extended access list that filters SSM traffic based on source address, group address, or both.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<p><b>ip multicast-routing</b> [<b>distributed</b>]</p> <p><b>Example:</b></p> <pre>Device(config)# ip multicast-routing distributed</pre>	Enables IP multicast routing. <ul style="list-style-type: none"> <li>• The <b>distributed</b> keyword is required for IPv4 multicast..</li> </ul>
<b>Step 4</b>	<p><b>ip pim ssm</b> {<b>default</b>   <b>range</b> <i>access-list</i>}</p>	Configures SSM service.

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config)# ip pim ssm default</pre>	<ul style="list-style-type: none"> <li>The <b>default</b> keyword defines the SSM range access list as 232/8.</li> <li>The <b>range</b> keyword specifies the standard IP access list number or name that defines the SSM range.</li> </ul>
<b>Step 5</b>	<p><b>ip access-list extended</b> <i>access-list -name</i></p> <p><b>Example:</b></p> <pre>Device(config)# ip access-list extended mygroup</pre>	Specifies an extended named IP access list.
<b>Step 6</b>	<p><b>deny igmp</b> <i>source source-wildcard destination destination-wildcard [igmp-type] [precedence precedence] [tos tos] [log] [time-range time-range-name] [fragments]</i></p> <p><b>Example:</b></p> <pre>Device(config-ext-nacl)# deny igmp host 10.1.2.3 any</pre>	<p>(Optional) Filters the specified source address or group address from the IGMP report, thereby restricting hosts on a subnet from membership to the (S, G) channel.</p> <ul style="list-style-type: none"> <li>Repeat this step to restrict hosts on a subnet membership to other (S, G) channels. (These sources should be more specific than a subsequent <b>permit</b> statement because any sources or groups not specifically permitted are denied.)</li> <li>Remember that the access list ends in an implicit <b>deny</b> statement.</li> <li>This example shows how to create a deny statement that filters all groups for source 10.1.2.3, which effectively denies the source.</li> </ul>
<b>Step 7</b>	<p><b>permit igmp</b> <i>source source-wildcard destination destination-wildcard [igmp-type] [precedence precedence] [tos tos] [log] [time-range time-range-name] [fragments]</i></p> <p><b>Example:</b></p> <pre>Device(config-ext-nacl)# permit igmp any any</pre>	<p>Allows a source address or group address in an IGMP report to pass the IP access list.</p> <ul style="list-style-type: none"> <li>You must have at least one <b>permit</b> statement in an access list.</li> <li>Repeat this step to allow other sources to pass the IP access list.</li> <li>This example shows how to allow group membership to sources and groups not denied by prior <b>deny</b> statements.</li> </ul>
<b>Step 8</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-ext-nacl)# exit</pre>	Exits the current configuration session and returns to global configuration mode.

	Command or Action	Purpose
<b>Step 9</b>	interface type number <b>Example:</b>  Device(config)# interface ethernet 0	Selects an interface that is connected to hosts on which IGMPv3 can be enabled.
<b>Step 10</b>	<b>ip igmp access-group</b> <i>access-list</i> <b>Example:</b>  Device(config-if)# ip igmp access-group mygroup	Applies the specified access list to IGMP reports.
<b>Step 11</b>	<b>ip pim sparse-mode</b> <b>Example:</b>  Device(config-if)# ip pim sparse-mode	Enables PIM-SM on the interface.  <b>Note</b> You must use sparse mode.
<b>Step 12</b>	Repeat Steps 1 through 11 on all interfaces that require access control of SSM channel membership.	--
<b>Step 13</b>	<b>ip igmp version 3</b> <b>Example:</b>  Device(config-if)# ip igmp version 3	Enables IGMPv3 on this interface. The default version of IGMP is IGMP version 2. Version 3 is required by SSM.
<b>Step 14</b>	Repeat Step 13 on all host-facing interfaces.	--
<b>Step 15</b>	<b>end</b> <b>Example:</b>  Device(config-if)# end	Returns to privileged EXEC mode.

## How to Configure IGMP Snooping

### Enabling IGMP Snooping

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 3</b>	<b>ip igmp snooping</b> <b>Example:</b> Device(config)# <code>ip igmp snooping</code>	Globally enables IGMP snooping after it has been disabled.
<b>Step 4</b>	<b>bridge-domain <i>bridge-id</i></b> <b>Example:</b> Device(config)# <code>bridge-domain 100</code>	(Optional) Enters bridge domain configuration mode.
<b>Step 5</b>	<b>ip igmp snooping</b> <b>Example:</b> Device(config-bdomain)# <code>ip igmp snooping</code>	(Optional) Enables IGMP snooping on the bridge domain interface being configured. <ul style="list-style-type: none"> <li>• Required only if IGMP snooping was previously explicitly disabled on the specified bridge domain.</li> </ul>
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config-bdomain)# <code>end</code>	Returns to privileged EXEC mode.

## Enabling or Disabling IGMP Snooping on a VLAN Interface (CLI)

Follow these steps to enable IGMP snooping on a VLAN interface:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>ip igmp snooping vlan <i>vlan-id</i></b> <b>Example:</b> <pre>Device(config)# ip igmp snooping vlan 7</pre>	Enables IGMP snooping on the VLAN interface. The VLAN ID range is 1 to 1001 and 1006 to 4094. IGMP snooping must be globally enabled before you can enable VLAN snooping. <b>Note</b> To disable IGMP snooping on a VLAN interface, use the <b>no ip igmp snooping vlan <i>vlan-id</i></b> global configuration command for the specified VLAN number.
<b>Step 4</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Setting the Snooping Method (CLI)

Multicast-capable router ports are added to the forwarding table for every Layer 2 multicast entry. The device learns of the ports through one of these methods:

- Snooping on IGMP queries, Protocol-Independent Multicast (PIM) packets
- Statically connecting to a multicast router port using the **ip igmp snooping mrouter** global configuration command

Beginning in privileged EXEC mode, follow these steps to alter the method in which a VLAN interface accesses a multicast router:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. Enter your password, if prompted.

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>ip igmp snooping vlan <i>vlan-id</i> mrouter interface {GigabitEthernet   Port-Channel   TenGigabitEthernet}</b> <b>Example:</b>  Device(config)# <code>ip igmp snooping vlan 1 mrouter interface GigabitEthernet1/0/3</code>	Enables IGMP snooping on a VLAN. The VLAN ID range is 1 to 1001 and 1006 to 4094.
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show ip igmp snooping</b> <b>Example:</b>  Device# <code>show ip igmp snooping</code>	Verifies the configuration.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring a Multicast Router Port (CLI)

Perform these steps to add a multicast router port (enable a static connection to a multicast router) on the device.



**Note** Static connections to multicast routers are supported only on device ports.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>	Enables privileged EXEC mode.



	Command or Action	Purpose
	<b>Example:</b>  Device> <b>enable</b>	<ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip igmp snooping vlan <i>vlan-id</i> mrouter interface <i>interface-id</i></b>  <b>Example:</b>  Device(config)# <b>ip igmp snooping vlan 5 mrouter interface gigabitethernet1/0/1</b>	Specifies the multicast router VLAN ID and the interface to the multicast router. <ul style="list-style-type: none"> <li>The VLAN ID range is 1 to 1001 and 1006 to 4094.</li> <li>The interface can be a physical interface or a port channel. The port-channel range is 1 to 128.</li> </ul> <p><b>Note</b> To remove a multicast router port from the VLAN, use the <b>no ip igmp snooping vlan <i>vlan-id</i> mrouter interface <i>interface-id</i></b> global configuration command.</p>
<b>Step 4</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show ip igmp snooping mrouter [vlan <i>vlan-id</i>]</b>  <b>Example:</b>  Device# <b>show ip igmp snooping mrouter vlan 5</b>	Verifies that IGMP snooping is enabled on the VLAN interface.
<b>Step 6</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring a Host Statically to Join a Group (CLI)

Hosts or Layer 2 ports normally join multicast groups dynamically, but you can also statically configure a host on an interface.

Follow these steps to add a Layer 2 port as a member of a multicast group:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip igmp snooping vlan <i>vlan-id</i> static <i>ip_address</i> interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>ip igmp snooping vlan 105 static 230.0.0.1 interface gigabitethernet1/0/1</b>	Statically configures a Layer 2 port as a member of a multicast group: <ul style="list-style-type: none"> <li>• <i>vlan-id</i> is the multicast group VLAN ID. The range is 1 to 1001 and 1006 to 4094.</li> <li>• <i>ip-address</i> is the group IP address.</li> <li>• <i>interface-id</i> is the member port. It can be a physical interface or a port channel (1 to 128).</li> </ul> <p><b>Note</b> To remove the Layer 2 port from the multicast group, use the <b>no ip igmp snooping vlan <i>vlan-id</i> static <i>mac-address</i> interface <i>interface-id</i></b> global configuration command.</p>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show ip igmp snooping groups</b> <b>Example:</b> Device# <b>show ip igmp snooping groups</b>	Verifies the member port and the IP address.

	Command or Action	Purpose
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Enabling IGMP Immediate Leave (CLI)

When you enable IGMP Immediate Leave, the device immediately removes a port when it detects an IGMP Version 2 leave message on that port. You should use the Immediate-Leave feature only when there is a single receiver present on every port in the VLAN.



**Note** Immediate Leave is supported only on IGMP Version 2 hosts. IGMP Version 2 is the default version for the device.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ip igmp snooping vlan <i>vlan-id</i> immediate-leave</b> <b>Example:</b> <pre>Device(config)# ip igmp snooping vlan 21 immediate-leave</pre>	Enables IGMP Immediate Leave on the VLAN interface. <p><b>Note</b> To disable IGMP Immediate Leave on a VLAN, use the <b>no ip igmp snooping vlan <i>vlan-id</i> immediate-leave</b> global configuration command.</p>
<b>Step 4</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 5</b>	<b>show ip igmp snooping vlan <i>vlan-id</i></b> <b>Example:</b> Device# <code>show ip igmp snooping vlan 21</code>	Verifies that Immediate Leave is enabled on the VLAN interface.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.

## Configuring the IGMP Leave Timer (CLI)

You can configure the leave time globally or on a per-VLAN basis. Follow these steps to enable the IGMP configurable-leave timer:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>ip igmp snooping last-member-query-interval <i>time</i></b> <b>Example:</b> Device(config)# <code>ip igmp snooping last-member-query-interval 1000</code>	Configures the IGMP leave timer globally. The range is 100 to 32767 milliseconds. The default leave time is 1000 milliseconds. <b>Note</b> To globally reset the IGMP leave timer to the default setting, use the <b>no ip igmp snooping last-member-query-interval</b> global configuration command.
<b>Step 4</b>	<b>ip igmp snooping vlan <i>vlan-id</i> last-member-query-interval <i>time</i></b> <b>Example:</b>	(Optional) Configures the IGMP leave time on the VLAN interface. The range is 100 to 32767 milliseconds.

	Command or Action	Purpose
	<pre>Device(config)# ip igmp snooping vlan 210 last-member-query-interval 1000</pre>	<p><b>Note</b> Configuring the leave time on a VLAN overrides the globally configured timer.</p> <p><b>Note</b> To remove the configured IGMP leave-time setting from the specified VLAN, use the <b>no ip igmp snooping vlan <i>vlan-id</i> last-member-query-interval</b> global configuration command.</p>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<p><b>show ip igmp snooping</b></p> <p><b>Example:</b></p> <pre>Device# show ip igmp snooping</pre>	(Optional) Displays the configured IGMP leave time.
<b>Step 7</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring the IGMP Robustness-Variable (CLI)

Use the following procedure to configure the IGMP robustness variable on the device.

The robustness variable is the integer used by IGMP snooping during calculations for IGMP messages. The robustness variable provides fine tuning to allow for expected packet loss.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <p>Enter your password, if prompted.</p>
<b>Step 2</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 3</b>	<b>ip igmp snooping robustness-variable</b> <i>count</i> <b>Example:</b> Device(config)# <code>ip igmp snooping robustness-variable 3</code>	Configures the IGMP robustness variable. The range is 1 to 3 times.  The recommended value for the robustness variable is 2. Use this command to change the value of the robustness variable for IGMP snooping from the default (2) to a specified value.
<b>Step 4</b>	<b>ip igmp snooping vlan</b> <i>vlan-id</i> <b>robustness-variable</b> <i>count</i> <b>Example:</b> Device(config)# <code>ip igmp snooping vlan 100 robustness-variable 3</code>	(Optional) Configures the IGMP robustness variable on the VLAN interface. The range is 1 to 3 times. The recommended value for the robustness variable is 2.  <b>Note</b> Configuring the robustness variable count on a VLAN overrides the globally configured value.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show ip igmp snooping</b> <b>Example:</b> Device# <code>show ip igmp snooping</code>	(Optional) Displays the configured IGMP robustness variable count.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring the IGMP Last Member Query Count (CLI)

To configure the number of times the device sends IGMP group-specific or group-source-specific (with IGMP version 3) query messages in response to receiving a group-specific or group-source-specific leave message, use this command.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. Enter your password, if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ip igmp snooping last-member-query-count</b> <i>count</i> <b>Example:</b> <pre>Device(config)# ip igmp snooping last-member-query-count 3</pre>	Configures the IGMP last member query count. The range is 1 to 7 messages. The default is 2 messages.
<b>Step 4</b>	<b>ip igmp snooping vlan</b> <i>vlan-id</i> <b>last-member-query-count</b> <i>count</i> <b>Example:</b> <pre>Device(config)#ip igmp snooping vlan 100 last-member-query-count 3</pre>	(Optional) Configures the IGMP last member query count on the VLAN interface. The range is 1 to 7 messages.  <b>Note</b> Configuring the last member query count on a VLAN overrides the globally configured timer.
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show ip igmp snooping</b> <b>Example:</b> <pre>Device# show ip igmp snooping</pre>	(Optional) Displays the configured IGMP last member query count.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring TCN-Related Commands

### Controlling the Multicast Flooding Time After a TCN Event (CLI)

You can configure the number of general queries by which multicast data traffic is flooded after a topology change notification (TCN) event. If you set the TCN flood query count to 1 the flooding stops after receiving 1 general query. If you set the count to 7, the flooding continues until 7 general queries are received. Groups are relearned based on the general queries received during the TCN event.

Some examples of TCN events are when the client location is changed and the receiver is on same port that was blocked but is now forwarding, and when a port goes down without sending a leave message.

Follow these steps to configure the TCN flood query count:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip igmp snooping tcn flood query count <i>count</i></b> <b>Example:</b> Device(config)# <b>ip igmp snooping tcn flood query count 3</b>	Specifies the number of IGMP general queries for which the multicast traffic is flooded. The range is 1 to 10. The default, the flooding query count is 2. <b>Note</b> To return to the default flooding query count, use the <b>no ip igmp snooping tcn flood query count</b> global configuration command.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show ip igmp snooping</b> <b>Example:</b> Device# <b>show ip igmp snooping</b>	Verifies the TCN settings.



	Command or Action	Purpose
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

### Recovering from Flood Mode (CLI)

When a topology change occurs, the spanning-tree root sends a special IGMP leave message (also known as global leave) with the group multicast address 0.0.0.0. However, you can enable the device to send the global leave message whether it is the spanning-tree root or not. When the router receives this special leave, it immediately sends general queries, which expedite the process of recovering from the flood mode during the TCN event. Leaves are always sent if the device is the spanning-tree root regardless of this configuration.

Follow these steps to enable sending of leave messages:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ip igmp snooping tcn query solicit</b> <b>Example:</b> <pre>Device(config)# ip igmp snooping tcn query solicit</pre>	Sends an IGMP leave message (global leave) to speed the process of recovering from the flood mode caused during a TCN event. By default, query solicitation is disabled. <p><b>Note</b> To return to the default query solicitation, use the <b>no ip igmp snooping tcn query solicit</b> global configuration command.</p>
<b>Step 4</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 5</b>	<b>show ip igmp snooping</b> <b>Example:</b> Device# <code>show ip igmp snooping</code>	Verifies the TCN settings.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

### Disabling Multicast Flooding During a TCN Event (CLI)

When the device receives a TCN, multicast traffic is flooded to all the ports until 2 general queries are received. If the device has many ports with attached hosts that are subscribed to different multicast groups, this flooding might exceed the capacity of the link and cause packet loss. Follow these steps to control TCN flooding:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <code>interface gigabitethernet 1/0/1</code>	Specifies the interface to be configured, and enters interface configuration mode.
<b>Step 4</b>	<b>no ip igmp snooping tcn flood</b> <b>Example:</b> Device(config-if)# <code>no ip igmp snooping tcn flood</code>	Disables the flooding of multicast traffic during a spanning-tree TCN event.  By default, multicast flooding is enabled on an interface.

	Command or Action	Purpose
		<b>Note</b> To re-enable multicast flooding on an interface, use the <b>ip igmp snooping tcn flood</b> interface configuration command.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show ip igmp snooping</b> <b>Example:</b>  Device# <b>show ip igmp snooping</b>	Verifies the TCN settings.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring the IGMP Snooping Querier (CLI)

Follow these steps to enable the IGMP snooping querier feature in a VLAN:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip igmp snooping querier</b> <b>Example:</b>  Device(config)# <b>ip igmp snooping querier</b>	Enables the IGMP snooping querier.

	Command or Action	Purpose
<b>Step 4</b>	<p><b>ip igmp snooping querier address</b> <i>ip_address</i></p> <p><b>Example:</b></p> <pre>Device(config)# ip igmp snooping querier address 172.16.24.1</pre>	<p>(Optional) Specifies an IP address for the IGMP snooping querier. If you do not specify an IP address, the querier tries to use the global IP address configured for the IGMP querier.</p> <p><b>Note</b> The IGMP snooping querier does not generate an IGMP general query if it cannot find an IP address on the device.</p>
<b>Step 5</b>	<p><b>ip igmp snooping querier query-interval</b> <i>interval-count</i></p> <p><b>Example:</b></p> <pre>Device(config)# ip igmp snooping querier query-interval 30</pre>	<p>(Optional) Sets the interval between IGMP queries. The range is 1 to 18000 seconds.</p>
<b>Step 6</b>	<p><b>ip igmp snooping querier tcn query</b> [<i>count count</i>   <i>interval interval</i>]</p> <p><b>Example:</b></p> <pre>Device(config)# ip igmp snooping querier tcn query interval 20</pre>	<p>(Optional) Sets the time between Topology Change Notification (TCN) queries. The count range is 1 to 10. The interval range is 1 to 255 seconds.</p>
<b>Step 7</b>	<p><b>ip igmp snooping querier timer expiry</b> <i>timeout</i></p> <p><b>Example:</b></p> <pre>Device(config)# ip igmp snooping querier timer expiry 180</pre>	<p>(Optional) Sets the length of time until the IGMP querier expires. The range is 60 to 300 seconds.</p>
<b>Step 8</b>	<p><b>ip igmp snooping querier version</b> <i>version</i></p> <p><b>Example:</b></p> <pre>Device(config)# ip igmp snooping querier version 2</pre>	<p>(Optional) Selects the IGMP version number that the querier feature uses. Select 1 or 2.</p>
<b>Step 9</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	<p>Returns to privileged EXEC mode.</p>

	Command or Action	Purpose
<b>Step 10</b>	<b>show ip igmp snooping vlan <i>vlan-id</i></b> <b>Example:</b> Device# <code>show ip igmp snooping vlan 30</code>	(Optional) Verifies that the IGMP snooping querier is enabled on the VLAN interface. The VLAN ID range is 1 to 1001 and 1006 to 4094.
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Disabling IGMP Report Suppression (CLI)

Follow these steps to disable IGMP report suppression:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>no ip igmp snooping report-suppression</b> <b>Example:</b> Device(config)# <code>no ip igmp snooping report-suppression</code>	Disables IGMP report suppression. When report suppression is disabled, all IGMP reports are forwarded to the multicast routers.  IGMP report suppression is enabled by default.  When IGMP report suppression is enabled, the device forwards only one IGMP report per multicast router query.  <b>Note</b> To re-enable IGMP report suppression, use the <b>ip igmp snooping report-suppression</b> global configuration command.
<b>Step 4</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	<code>Device(config)# end</code>	
<b>Step 5</b>	<b>show ip igmp snooping</b> <b>Example:</b>  <code>Device# show ip igmp snooping</code>	Verifies that IGMP report suppression is disabled.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>  <code>Device# copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Monitoring IGMP

You can display specific statistics, such as the contents of IP routing tables, caches, and databases.



**Note** This release does not support per-route statistics.

You can display information to learn resource usage and solve network problems. You can also display information about node reachability and discover the routing path that packets of your device are taking through the network.

You can use any of the privileged EXEC commands in the following table to display various routing statistics.

**Table 39: Commands for Displaying System and Network Statistics**

Command	Purpose
<code>ping [group-name   group-address]</code>	Sends an ICMP Echo Request to a multicast group address.
<code>show ip igmp filter</code>	Displays IGMP filter information.
<code>show ip igmp groups [type-number   detail]</code>	Displays the multicast groups that are directly connected to the device and that were learned through IGMP.
<code>show ip igmp interface [type number]</code>	Displays multicast-related information about an interface.
<code>show ip igmp membership [ name/group address   all   tracked ]</code>	Displays IGMP membership information for forwarding.

Command	Purpose
<code>show ip igmp profile [ profile_number ]</code>	Displays IGMP profile information.
<code>show ip igmp ssm-mapping [ hostname/IP address ]</code>	Displays IGMP SSM mapping information.
<code>show ip igmp static-group {class-map [ interface [ type ] ]}</code>	Displays static group information.
<code>show ip igmp vrf</code>	Displays the selected VPN routing/forwarding instance by name.

## Monitoring IGMP Snooping Information

You can display IGMP snooping information for dynamically learned and statically configured router ports and VLAN interfaces. You can also display MAC address multicast entries for a VLAN configured for IGMP snooping.

**Table 40: Commands for Displaying IGMP Snooping Information**

Command	Purpose
<code>show ip igmp snooping detail</code>	Displays the operational state information.
<code>show ip igmp snooping groups [ count   [vlan vlan-id [A.B.C.D   count ] ]</code>	Displays multicast table information for the device or about a specific parameter: <ul style="list-style-type: none"> <li>• <b>count</b>—Displays the total number of groups.</li> <li>• <b>vlan</b>—Displays group information by VLAN ID.</li> </ul>
<code>show ip igmp snooping igmpv2-tracking</code>	Displays the IGMP snooping tracking. <p><b>Note</b> This command displays group and IP address entries only for wireless multicast IGMP joins and not for wired IGMP joins. Wireless IP multicast must be enabled for this command to display.</p>
<code>show ip igmp snooping mrouter [vlan vlan-id]</code>	Displays information on dynamically learned and manually configured multicast router interfaces. <p><b>Note</b> When you enable IGMP snooping, the device automatically learns the interface to which a multicast router is connected. These are dynamically learned interfaces.</p> <p>(Optional) Enter <b>vlan vlan-id</b> to display information for a single VLAN.</p>

Command	Purpose
<code>show ip igmp snooping querier [ detail   vlan <i>vlan-id</i>]</code>	Displays information about the IP address and receiving port for the most-recently received IGMP query messages in the VLAN.  (Optional) Enter <b>detail</b> to display the detailed IGMP querier information in a VLAN.  (Optional) Enter <b>vlan <i>vlan-id</i></b> to display information for a single VLAN.
<code>show ip igmp snooping [vlan <i>vlan-id</i> [ detail ] ]</code>	Displays the snooping configuration information for all VLANs on the device or for a specified VLAN.  (Optional) Enter <b>vlan <i>vlan-id</i></b> to display information for a single VLAN. The VLAN ID range is 1 to 1001 and 1006 to 4094.
<code>show ip igmp snooping wireless mgid</code>	Displays wireless-related events.

## Monitoring IGMP Filtering and Throttling Configuration

You can display IGMP profile characteristics, and you can display the IGMP profile and maximum group configuration for all interfaces on the device or for a specified interface. You can also display the IGMP throttling configuration for all interfaces on the device or for a specified interface.

*Table 41: Commands for Displaying IGMP Filtering and Throttling Configuration*

Command	Purpose
<code>show ip igmp profile [<i>profile number</i>]</code>	Displays the specified IGMP profile or all the IGMP profiles defined on the device.
<code>show running-config [interface <i>interface-id</i>]</code>	Displays the configuration of the specified interface or the configuration of all interfaces on the device, including (if configured) the maximum number of IGMP groups to which an interface can belong and the IGMP profile applied to the interface.

## Configuration Examples for IGMP

### Example: Configuring the Device as a Member of a Multicast Group

This example shows how to enable the device to join multicast group 255.2.2.2:

```
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip igmp join-group 255.2.2.2
Device(config-if)#
```



## Example: Controlling Access to Multicast Groups

To limit the number of joins on the interface, configure the port for filter which associates with the IGMP profile.

```
Device# configure terminal
Device(config)# ip igmp profile 10
Device(config-igmp-profile)# ?

IGMP profile configuration commands:
deny matching addresses are denied
exit Exit from igmp profile configuration mode
no Negate a command or set its defaults
permit matching addresses are permitted
range add a range to the set

Device(config-igmp-profile)# range 172.16.5.1
Device(config-igmp-profile)# exit
Device(config)#
Device(config)# interface gigabitEthernet 2/0/10
Device(config-if)# ip igmp filter 10
```

## Examples: Configuring IGMP Snooping

This example shows how to enable a static connection to a multicast router:

```
Device# configure terminal
Device(config)# ip igmp snooping vlan 200 mrouter interface gigabitEthernet1/0/2
Device(config)# end
```

This example shows how to statically configure a host on a port:

```
Device# configure terminal
Device(config)# ip igmp snooping vlan 105 static 224.2.4.12 interface gigabitEthernet1/0/1
Device(config)# end
```

This example shows how to enable IGMP Immediate Leave on VLAN 130:

```
Device# configure terminal
Device(config)# ip igmp snooping vlan 130 immediate-leave
Device(config)# end
```

This example shows how to set the IGMP snooping querier source address to 10.0.0.64:

```
Device# configure terminal
Device(config)# ip igmp snooping querier 10.0.0.64
Device(config)# end
```

This example shows how to set the IGMP snooping querier maximum response time to 25 seconds:

```
Device# configure terminal
```

**Example: Configuring IGMP Profiles**

```
Device(config)# ip igmp snooping querier query-interval 25
Device(config)# end
```

This example shows how to set the IGMP snooping querier timeout to 60 seconds:

```
Device# configure terminal
Device(config)# ip igmp snooping querier timer expiry 60
Device(config)# end
```

This example shows how to set the IGMP snooping querier feature to Version 2:

```
Device# configure terminal
Device(config)# no ip igmp snooping querier version 2
Device(config)# end
```

**Example: Configuring IGMP Profiles**

This example shows how to create IGMP profile 4 allowing access to the single IP multicast address and how to verify the configuration. If the action was to deny (the default), it would not appear in the **show ip igmp profile** output display.

```
Device(config)# ip igmp profile 4
Device(config-igmp-profile)# permit
Device(config-igmp-profile)# range 229.9.9.0
Device(config-igmp-profile)# end
Device# show ip igmp profile 4
IGMP Profile 4
    permit
    range 229.9.9.0 229.9.9.0
```

**Example: Applying IGMP Profile**

This example shows how to apply IGMP profile 4 to a port:

```
Device(config)# interface gigabitethernet1/0/2
Device(config-if)# ip igmp filter 4
Device(config-if)# end
```

**Example: Setting the Maximum Number of IGMP Groups**

This example shows how to limit to 25 the number of IGMP groups that a port can join:

```
Device(config)# interface gigabitethernet1/0/2
Device(config-if)# ip igmp max-groups 25
Device(config-if)# end
```

## Example: Interface Configuration as a Routed Port

This example shows how to configure an interface on the device as a routed port. This configuration is required on the interface for several IP multicast routing configuration procedures that require running the **no switchport** command.

```
Device configure terminal
Device(config)# interface GigabitEthernet1/0/9
Device(config-if)# description interface to be use as routed port
Device(config-if)# no switchport
Device(config-if)# ip address 10.20.20.1 255.255.255.0
Device(config-if)# ip pim sparse-mode
Device(config-if)# ip igmp join-group 224.1.2.3 source 15.15.15.2
Device(config-if)# end
Device# configure terminal
Device# show run interface gigabitEthernet 1/0/9

Current configuration : 166 bytes
!
interface GigabitEthernet1/0/9
 no switchport
 ip address 10.20.20.1 255.255.255.0
 ip pim sparse-mode
 ip igmp static-group 224.1.2.3 source 15.15.15.2
end
```

## Example: Interface Configuration as an SVI

This example shows how to configure an interface on the device as an SVI. This configuration is required on the interface for several IP multicast routing configuration procedures that require running the **no switchport** command.

```
Device(config)# interface vlan 150
Device(config-if)# ip address 10.20.20.1 255.255.255.0
Device(config-if)# ip pim sparse-mode
Device(config-if)# ip igmp join-group 224.1.2.3 source 15.15.15.2
Device(config-if)# end
Device# configure terminal
Device(config)# ip igmp snooping vlan 20 static 224.1.2.3
Device(config)# interface gigabitEthernet 1/0/9
Device# show run interface vlan 150

Current configuration : 137 bytes
!
interface Vlan150
 ip address 10.20.20.1 255.255.255.0
 ip pim sparse-mode
 ip igmp static-group 224.1.2.3 source 15.15.15.2
end
```

## Example: Configuring the Device to Forward Multicast Traffic in the Absence of Directly Connected IGMP Hosts

The following example shows how to configure a device to forward multicast traffic in the absence of directly connected IGMP hosts using the **ip igmp join-group** command. With this method, the device accepts the multicast packets in addition to forwarding them. Accepting the multicast packets prevents the device from fast switching.

In this example, Fast Ethernet interface 0/0/0 on the device is configured to join the group 225.2.2.2:

```
interface FastEthernet0/0/0
 ip igmp join-group 225.2.2.2
```

The following example shows how to configure a device to forward multicast traffic in the absence of directly connected IGMP hosts using the **ip igmp static-group** command. With this method, the device does not accept the packets itself, but only forwards them. Hence, this method allows fast switching. The outgoing interface appears in the IGMP cache, but the device itself is not a member, as evidenced by lack of an “L” (local) flag in the multicast route entry.

In this example, static group membership entries for group 225.2.2.2 are configured on Fast Ethernet interface 0/1/0:

```
interface FastEthernet0/1/0
 ip igmp static-group 225.2.2.2
```

## Controlling Access to an SSM Network Using IGMP Extended Access Lists

This section contains the following configuration examples for controlling access to an SSM network using IGMP extended access lists:



### Note

Keep in mind that access lists are very flexible: there are many combinations of permit and deny statements one could use in an access list to filter multicast traffic. The examples in this section simply provide a few examples of how it can be done.

### Example: Denying All States for a Group G

The following example shows how to deny all states for a group G. In this example, Fast Ethernet interface 0/0/0 is configured to filter all sources for SSM group 232.2.2.2 in IGMPv3 reports, which effectively denies this group.

```
ip access-list extended test1
 deny igmp any host 232.2.2.2
 permit igmp any any
!
interface FastEthernet0/0/0
 ip igmp access-group test1
```

## Example: Denying All States for a Source S

The following example shows how to deny all states for a source S. In this example, Gigabit Ethernet interface 1/1/0 is configured to filter all groups for source 10.2.1.32 in IGMPv3 reports, which effectively denies this source.

```
ip access-list extended test2
 deny igmp host 10.2.1.32 any
 permit igmp any any
!
interface GigabitEthernet1/1/0
 ip igmp access-group test2
```

## Example: Permitting All States for a Group G

The following example shows how to permit all states for a group G. In this example, Gigabit Ethernet interface 1/2/0 is configured to accept all sources for SSM group 232.1.1.10 in IGMPv3 reports, which effectively accepts this group altogether.

```
ip access-list extended test3
 permit igmp any host 232.1.1.10
!
interface GigabitEthernet1/2/0
 ip igmp access-group test3
```

## Example: Permitting All States for a Source S

The following example shows how to permit all states for a source S. In this example, Gigabit Ethernet interface 1/2 is configured to accept all groups for source 10.6.23.32 in IGMPv3 reports, which effectively accepts this source altogether.

```
ip access-list extended test4
 permit igmp host 10.6.23.32 any
!
interface GigabitEthernet1/2/0
 ip igmp access-group test4
```

## Example: Filtering a Source S for a Group G

The following example shows how to filter a particular source S for a group G. In this example, Gigabit Ethernet interface 0/3/0 is configured to filter source 232.2.2.2 for SSM group 232.2.30.30 in IGMPv3 reports.

```
ip access-list extended test5
 deny igmp host 10.4.4.4 host 232.2.30.30
 permit igmp any any
!
interface GigabitEthernet0/3/0
 ip igmp access-group test5
```

# Additional References

## Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	<i>IP Multicast Routing Command Reference (Catalyst 3850 Switches)</i>
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
Cisco IOS IP SLAs commands	<a href="#">Cisco IOS IP Multicast Command Reference</a>

## Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

## Standards and RFCs

Standard/RFC	Title
RFC 1112	Host Extensions for IP Multicasting
RFC 2236	Internet Group Management Protocol, Version 2
RFC 3376	<i>Internet Group Management Protocol, Version 3</i>

## MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for IGMP

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.







## CHAPTER 29

# Configuring IGMP Proxy

- [Prerequisites for IGMP Proxy, on page 499](#)
- [Information about IGMP Proxy, on page 499](#)
- [How to Configure IGMP Proxy, on page 501](#)
- [Configuration Examples for IGMP Proxy, on page 504](#)
- [Additional References, on page 505](#)
- [Feature History and Information for IGMP Proxy, on page 506](#)

## Prerequisites for IGMP Proxy

- All devices on the IGMP UDL have the same subnet address. If all devices on the UDL cannot have the same subnet address, the upstream device must be configured with secondary addresses to match all of the subnets to which the downstream devices are attached.
- IP multicast is enabled and the PIM interfaces are configured.



---

**Note** Use the following guidelines when configuring PIM interfaces for IGMP proxy:

---

- Use PIM sparse mode (PIM-SM) when the interface is operating in a sparse-mode region and you are running static RP, bootstrap (BSR), or Auto-RP with the Auto-RP listener capability.

## Information about IGMP Proxy

### IGMP Proxy

An IGMP proxy enables hosts in a unidirectional link routing (UDLR) environment that are not directly connected to a downstream router to join a multicast group sourced from an upstream network.

The figure below illustrates a sample topology that shows two UDLR scenarios:

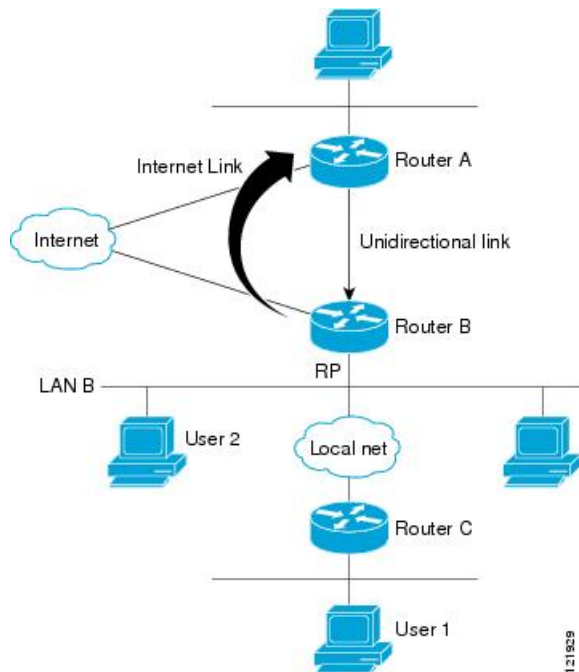
- Traditional UDL routing scenario--A UDL device with directly connected receivers.
- IGMP proxy scenario--UDL device without directly connected receivers.



**Note** IGMP UDLs are needed on the upstream and downstream devices.



**Note** Although the following illustration and example uses routers in the configuration, any device (router or switch) can be used.



### Scenario 1--Traditional UDLR Scenario (UDL Device with Directly Connected Receivers)

For scenario 1, no IGMP proxy mechanism is needed. In this scenario, the following sequence of events occurs:

1. User 2 sends an IGMP membership report requesting interest in group G.
2. Router B receives the IGMP membership report, adds a forwarding entry for group G on LAN B, and proxies the IGMP report to Router A, which is the UDLR upstream device.
3. The IGMP report is then proxied across the Internet link.
4. Router A receives the IGMP proxy and maintains a forwarding entry on the unidirectional link.

### Scenario 2--IGMP Proxy Scenario (UDL Device without Directly Connected Receivers)

For scenario 2, the IGMP proxy mechanism is needed to enable hosts that are not directly connected to a downstream device to join a multicast group sourced from an upstream network. In this scenario, the following sequence of events occurs:

1. User 1 sends an IGMP membership report requesting interest in group G.

2. Router C sends a PIM Join message hop-by-hop to the RP (Router B).
3. Router B receives the PIM Join message and adds a forwarding entry for group G on LAN B.
4. Router B periodically checks its mroute table and proxies the IGMP membership report to its upstream UDL device across the Internet link.
5. Router A creates and maintains a forwarding entry on the unidirectional link (UDL).

In an enterprise network, it is desirable to be able to receive IP multicast traffic via satellite and forward the traffic throughout the network. With unidirectional link routing (UDLR) alone, scenario 2 would not be possible because receiving hosts must be directly connected to the downstream device, Router B. The IGMP proxy mechanism overcomes this limitation by creating an IGMP report for (\*, G) entries in the multicast forwarding table. To make this scenario functional, therefore, you must enable IGMP report forwarding of proxied (\*, G) multicast static route (mroute) entries (using the **ip igmp mroute-proxy** command) and enable the mroute proxy service (using the **ip igmp proxy-service** command) on interfaces leading to PIM-enabled networks with potential members.



**Note** Because PIM messages are not forwarded upstream, each downstream network and the upstream network have a separate domain.

## How to Configure IGMP Proxy

### Configuring the Upstream UDL Device for IGMP UDLR

Perform this task to configure the upstream UDL device for IGMP UDLR.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>type number</i> <b>Example:</b> Device(config)# interface gigabitethernet 1/0/0	Enters interface configuration mode. <ul style="list-style-type: none"> <li>• For the <i>type</i> and <i>number</i> arguments, specify the interface to be used as the UDL on the upstream device.</li> </ul>

	Command or Action	Purpose
<b>Step 4</b>	<b>ip igmp unidirectional-link</b> <b>Example:</b> <pre>Device(config-if)# ip igmp unidirectional-link</pre>	Configures IGMP on the interface to be unidirectional for IGMP UDLR.
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config-if)# end</pre>	Ends the current configuration session and returns to privileged EXEC mode.

## Configuring the Downstream UDL Device for IGMP UDLR with IGMP Proxy Support

Perform this task to configure the downstream UDL device for IGMP UDLR with IGMP proxy support.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>type number</i></b> <b>Example:</b> <pre>Device(config)# interface gigabitethernet 0/0/0</pre>	Enters interface configuration mode. <ul style="list-style-type: none"> <li>• For the <i>type</i> and <i>number</i> arguments, specify the interface to be used as the UDL on the downstream device for IGMP UDLR.</li> </ul>
<b>Step 4</b>	<b>ip igmp unidirectional-link</b> <b>Example:</b> <pre>Device(config-if)# ip igmp unidirectional-link</pre>	Configures IGMP on the interface to be unidirectional for IGMP UDLR.
<b>Step 5</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-if)# exit</pre>	Exits interface configuration mode and returns to global configuration mode.

	Command or Action	Purpose
<b>Step 6</b>	<b>interface</b> <i>type number</i> <b>Example:</b> <pre>Device(config)# interface gigabitethernet 1/0/0</pre>	Enters interface configuration mode. <ul style="list-style-type: none"> <li>For the <i>type</i> and <i>number</i> arguments, select an interface that is facing the nondirectly connected hosts.</li> </ul>
<b>Step 7</b>	<b>ip igmp mroute-proxy</b> <i>type number</i> <b>Example:</b> <pre>Device(config-if)# ip igmp mroute-proxy loopback 0</pre>	Enables IGMP report forwarding of proxied (*, G) multicast static route (mroute) entries. <ul style="list-style-type: none"> <li>This step is performed to enable the forwarding of IGMP reports to a proxy service interface for all (*, G) forwarding entries in the multicast forwarding table.</li> <li>In this example, the <b>ip igmp mroute-proxy</b> command is configured on Gigabit Ethernet interface 1/0/0 to request that IGMP reports be sent to loopback interface 0 for all groups in the mroute table that are forwarded to Gigabit Ethernet interface 1/0/0.</li> </ul>
<b>Step 8</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-if)# exit</pre>	Exits interface configuration mode and returns to global configuration mode.
<b>Step 9</b>	<b>interface</b> <i>type number</i> <b>Example:</b> <pre>Device(config)# interface loopback 0</pre>	Enters interface configuration mode for the specified interface. <ul style="list-style-type: none"> <li>In this example, loopback interface 0 is specified.</li> </ul>
<b>Step 10</b>	<b>ip igmp helper-address udl</b> <i>interface-type interface-number</i> <b>Example:</b> <pre>Device(config-if)# ip igmp helper-address udl gigabitethernet 0/0/0</pre>	Configures IGMP helping for UDL. <ul style="list-style-type: none"> <li>This step allows the downstream device to helper IGMP reports received from hosts to an upstream device connected to a UDL associated with the interface specified for the <i>interface-type</i> and <i>interface-number</i> arguments.</li> <li>In the example topology, IGMP helping is configured over loopback interface 0 on the downstream device. Loopback interface 0, thus, is configured to helper IGMP reports from hosts to an upstream device connected to Gigabit Ethernet interface 0/0/0.</li> </ul>
<b>Step 11</b>	<b>ip igmp proxy-service</b>	Enables the mroute proxy service.

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config-if)# ip igmp proxy-service</pre>	<ul style="list-style-type: none"> <li>When the mroute proxy service is enabled, the device periodically checks the static mroute table for (*, G) forwarding entries that match interfaces configured with the <b>ip igmp mroute-proxy</b> command (see Step 7) based on the IGMP query interval. Where there is a match, one IGMP report is created and received on this interface.</li> </ul> <p><b>Note</b> The <b>ip igmp proxy-service</b> command is intended to be used with the <b>ip igmp helper-address</b> (UDL) command.</p> <ul style="list-style-type: none"> <li>In this example, the <b>ip igmp proxy-service</b> command is configured on loopback interface 0 to enable the forwarding of IGMP reports out the interface for all groups on interfaces registered through the <b>ip igmp mroute-proxy</b> command (see Step 7).</li> </ul>
<b>Step 12</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# end</pre>	Ends the current configuration session and returns to privileged EXEC mode.
<b>Step 13</b>	<p><b>show ip igmp interface</b></p> <p><b>Example:</b></p> <pre>Device# show ip igmp interface</pre>	(Optional) Displays multicast-related information about an interface.
<b>Step 14</b>	<p><b>show ip igmp udlr</b></p> <p><b>Example:</b></p> <pre>Device# show ip igmp udlr</pre>	(Optional) Displays UDLR information for directly connected multicast groups on interfaces that have a UDL helper address configured.

## Configuration Examples for IGMP Proxy

### Example: IGMP Proxy Configuration

The following example shows how to configure the upstream UDL device for IGMP UDLR and the downstream UDL device for IGMP UDLR with IGMP proxy support.

### Upstream Device Configuration

```
interface gigabitethernet 0/0/0
ip address 10.1.1.1 255.255.255.0
ip pim sparse-mode
!
interface gigabitethernet 1/0/0
ip address 10.2.1.1 255.255.255.0
ip pim sparse-mode
ip igmp unidirectional-link
!
interface gigabitethernet 2/0/0
ip address 10.3.1.1 255.255.255.0
```

### Downstream Device Configuration

```
ip pim rp-address 10.5.1.1 5
access-list 5 permit 239.0.0.0 0.255.255.255
!
interface loopback 0
ip address 10.7.1.1 255.255.255.0
ip pim sparse-mode
ip igmp helper-address udl ethernet 0
ip igmp proxy-service
!
interface gigabitethernet 0/0/0
ip address 10.2.1.2 255.255.255.0
ip pim sparse-mode
ip igmp unidirectional-link
!
interface gigabitethernet 1/0/0
ip address 10.5.1.1 255.255.255.0
ip pim sparse-mode
ip igmp mroute-proxy loopback 0
!
interface gigabitethernet 2/0/0
ip address 10.6.1.1 255.255.255.0
```

## Additional References

The following sections provide references related to customizing IGMP.

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
Cisco IOS IP SLAs commands	<a href="#">Cisco IOS IP Multicast Command Reference</a>
Overview of the IP multicast technology area	“IP Multicast Technology Overview” module
Basic IP multicast concepts, configuration tasks, and examples	“Configuring Basic IP Multicast” or “Configuring IP Multicast in IPv6 Networks” module

**Standards and RFCs**

Standard/RFC	Title
RFC 1112	<i>Host extensions for IP multicasting</i>
RFC 2236	<i>Internet Group Management Protocol, Version 2</i>
RFC 3376	<i>Internet Group Management Protocol, Version 3</i>

**MIBs**

MIB	MIBs Link
No new or modified MIBs are supported by these features, and support for existing MIBs has not been modified by these features.	To locate and download MIBs for selected platforms, Cisco IOS XE releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

## Feature History and Information for IGMP Proxy

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.





## CHAPTER 30

# Constraining IP Multicast in Switched Ethernet

- [Prerequisites for Constraining IP Multicast in a Switched Ethernet Network, on page 507](#)
- [Information About IP Multicast in a Switched Ethernet Network, on page 507](#)
- [How to Constrain Multicast in a Switched Ethernet Network, on page 509](#)
- [Configuration Examples for Constraining IP Multicast in a Switched Ethernet Network, on page 511](#)
- [Additional References, on page 512](#)
- [Feature History and Information for Constraining IP Multicast in a Switched Ethernet Network, on page 513](#)

## Prerequisites for Constraining IP Multicast in a Switched Ethernet Network

Before using the tasks in this module, you should be familiar with the concepts described in the “IP Multicast Technology Overview” module.

## Information About IP Multicast in a Switched Ethernet Network

### IP Multicast Traffic and Layer 2 Switches

The default behavior for a Layer 2 switch is to forward all multicast traffic to every port that belongs to the destination LAN on the switch. This behavior reduces the efficiency of the switch, whose purpose is to limit traffic to the ports that need to receive the data. This behavior requires a constraining mechanism to reduce unnecessary multicast traffic, which improves switch performance.

Cisco Group Management Protocol (CGMP), Router Group Management Protocol (RGMP), and IGMP snooping efficiently constrain IP multicast in a Layer 2 switching environment.

- CGMP and IGMP snooping are used on subnets that include end users or receiver clients.
- RGMP is used on routed segments that contain only routers, such as in a collapsed backbone.
- RGMP and CGMP cannot interoperate. However, Internet Group Management Protocol (IGMP) can interoperate with CGMP and RGMP snooping.

## CGMP on Catalyst Switches for IP Multicast

CGMP is a Cisco-developed protocol used on device connected to Catalyst switches to perform tasks similar to those performed by IGMP. CGMP is necessary for those Catalyst switches that do not distinguish between IP multicast data packets and IGMP report messages, both of which are addressed to the same group address at the MAC level. The switch can distinguish IGMP packets, but would need to use software on the switch, greatly impacting its performance.

You must configure CGMP on the multicast device and the Layer 2 switches. The result is that, with CGMP, IP multicast traffic is delivered only to those Catalyst switch ports that are attached to interested receivers. All other ports that have not explicitly requested the traffic will not receive it unless these ports are connected to a multicast router. Multicast router ports must receive every IP multicast data packet.

Using CGMP, when a host joins a multicast group, it multicasts an unsolicited IGMP membership report message to the target group. The IGMP report is passed through the switch to the router for normal IGMP processing. The router (which must have CGMP enabled on this interface) receives the IGMP report and processes it as it normally would, but also creates a CGMP Join message and sends it to the switch. The Join message includes the MAC address of the end station and the MAC address of the group it has joined.

The switch receives this CGMP Join message and then adds the port to its content-addressable memory (CAM) table for that multicast group. All subsequent traffic directed to this multicast group is then forwarded out the port for that host.

The Layer 2 switches are designed so that several destination MAC addresses could be assigned to a single physical port. This design allows switches to be connected in a hierarchy and also allows many multicast destination addresses to be forwarded out a single port.

The device port also is added to the entry for the multicast group. Multicast device must listen to all multicast traffic for every group because IGMP control messages are also sent as multicast traffic. The rest of the multicast traffic is forwarded using the CAM table with the new entries created by CGMP.

## IGMP Snooping

IGMP snooping is an IP multicast constraining mechanism that runs on a Layer 2 LAN switch. IGMP snooping requires the LAN switch to examine, or “snoop,” some Layer 3 information (IGMP Join/Leave messages) in the IGMP packets sent between the hosts and the router. When the switch receives the IGMP host report from a host for a particular multicast group, the switch adds the port number of the host to the associated multicast table entry. When the switch hears the IGMP Leave group message from a host, the switch removes the table entry of the host.

Because IGMP control messages are sent as multicast packets, they are indistinguishable from multicast data at Layer 2. A switch running IGMP snooping must examine every multicast data packet to determine if it contains any pertinent IGMP control information. IGMP snooping implemented on a low-end switch with a slow CPU could have a severe performance impact when data is sent at high rates. The solution is to implement IGMP snooping on high-end switches with special application-specific integrated circuits (ASICs) that can perform the IGMP checks in hardware. CGMP is a better option for low-end switches without special hardware.

## Router-Port Group Management Protocol (RGMP)

CGMP and IGMP snooping are IP multicast constraining mechanisms designed to work on routed network segments that have active receivers. They both depend on IGMP control messages that are sent between the hosts and the routers to determine which switch ports are connected to interested receivers.

Switched Ethernet backbone network segments typically consist of several routers connected to a switch without any hosts on that segment. Because routers do not generate IGMP host reports, CGMP and IGMP snooping will not be able to constrain the multicast traffic, which will be flooded to every port on the VLAN. Routers instead generate Protocol Independent Multicast (PIM) messages to Join and Prune multicast traffic flows at a Layer 3 level.

Router-Port Group Management Protocol (RGMP) is an IP multicast constraining mechanism for router-only network segments. RGMP must be enabled on the routers and on the Layer 2 switches. A multicast router indicates that it is interested in receiving a data flow by sending an RGMP Join message for a particular group. The switch then adds the appropriate port to its forwarding table for that multicast group--similar to the way it handles a CGMP Join message. IP multicast data flows will be forwarded only to the interested router ports. When the router no longer is interested in that data flow, it sends an RGMP Leave message and the switch removes the forwarding entry.

If there are any routers that are not RGMP-enabled, they will continue to receive all multicast data.

## How to Constrain Multicast in a Switched Ethernet Network

### Configuring Switches for IP Multicast

If you have switching in your multicast network, consult the documentation for the switch you are working with for information about how to configure IP multicast.

### Configuring IGMP Snooping

No configuration is required on the router. Consult the documentation for the switch you are working with to determine how to enable IGMP snooping and follow the provided instructions.

### Enabling CGMP

CGMP is a protocol used on devices connected to Catalyst switches to perform tasks similar to those performed by IGMP. CGMP is necessary because the Catalyst switch cannot distinguish between IP multicast data packets and IGMP report messages, which are both at the MAC level and are addressed to the same group address.



#### Note

- CGMP should be enabled only on 802 or ATM media, or LAN emulation (LANE) over ATM.
- CGMP should be enabled only on devices connected to Catalyst switches.

#### Procedure

	Command or Action	Purpose
Step 1	<b>enable</b>  <b>Example:</b>  Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>type number</i> <b>Example:</b>  Device(config)# interface ethernet 1	Selects an interface that is connected to hosts on which IGMPv3 can be enabled.
<b>Step 4</b>	<b>ip cgmp</b> [ <b>proxy</b>   <b>router-only</b> ] <b>Example:</b>  Device(config-if)# ip cgmp proxy	Enables CGMP on an interface of a device connected to a Cisco Catalyst 5000 family switch. <ul style="list-style-type: none"> <li>The <b>proxy</b> keyword enables the CGMP proxy function. When enabled, any device that is not CGMP-capable will be advertised by the proxy router. The proxy router advertises the existence of other non-CGMP-capable devices by sending a CGMP Join message with the MAC address of the non-CGMP-capable device and group address of 0000.0000.0000.</li> </ul>
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config-if)# end	Ends the current configuration session and returns to EXEC mode.
<b>Step 6</b>	<b>clear ip cgmp</b> [ <i>interface-type</i> <i>interface-number</i> ] <b>Example:</b>  Device# clear ip cgmp	(Optional) Clears all group entries from the caches of Catalyst switches.

## Configuring IP Multicast in a Layer 2 Switched Ethernet Network

Perform this task to configure IP multicast in a Layer 2 Switched Ethernet network using RGMP.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface type number</b> <b>Example:</b>  Device(config)# interface ethernet 1	Selects an interface that is connected to hosts.
<b>Step 4</b>	<b>ip rgmp</b> <b>Example:</b>  Device(config-if)# ip rgmp	Enables RGMP on Ethernet, Fast Ethernet, and Gigabit Ethernet interfaces.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config-if)# end	Ends the current configuration session and returns to EXEC mode.
<b>Step 6</b>	<b>debug ip rgmp</b> <b>Example:</b>  Device# debug ip rgmp	(Optional) Logs debug messages sent by an RGMP-enabled device.
<b>Step 7</b>	<b>show ip igmp interface</b> <b>Example:</b>  Device# show ip igmp interface	(Optional) Displays multicast-related information about an interface.

## Configuration Examples for Constraining IP Multicast in a Switched Ethernet Network

### Example: CGMP Configuration

The following example is for a basic network environment where multicast source(s) and multicast receivers are in the same VLAN. The desired behavior is that the switch will constrain the multicast forwarding to those ports that request the multicast stream.

A 4908G-L3 router is connected to the Catalyst 4003 on port 3/1 in VLAN 50. The following configuration is applied on the GigabitEthernet1 interface. Note that there is no **ip multicast-routing** command configured because the router is not routing multicast traffic across its interfaces.

## RGMP Configuration Example

The following example shows how to configure RGMP on a router:

```
ip multicast-routing
ip pim sparse-mode
interface ethernet 0
 ip rgmp
```

## Additional References

The following sections provide references related to constraining IP multicast in a switched Ethernet network.

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
Cisco IOS IP SLAs commands	<a href="#">Cisco IOS IP Multicast Command Reference</a>
IGMP snooping	The “IGMP Snooping” module of the <i>IP Multicast: IGMP Configuration Guide</i>
RGMP	The “Configuring Router-Port Group Management Protocol” module of the <i>IP Multicast: IGMP Configuration Guide</i>

### MIBs

MIB	MIBs Link
None	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
Technical Assistance Center (TAC) home page, containing 30,000 pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	<a href="http://www.cisco.com/public/support/tac/home.shtml">http://www.cisco.com/public/support/tac/home.shtml</a>

## Feature History and Information for Constraining IP Multicast in a Switched Ethernet Network

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.







## CHAPTER 31

# Configuring Protocol Independent Multicast (PIM)

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- [Finding Feature Information, on page 515](#)
- [Prerequisites for PIM, on page 515](#)
- [Restrictions for PIM, on page 516](#)
- [Information About PIM, on page 519](#)
- [How to Configure PIM, on page 534](#)
- [Verifying PIM Operations, on page 560](#)
- [Monitoring and Troubleshooting PIM, on page 569](#)
- [Configuration Examples for PIM, on page 571](#)
- [Additional References, on page 574](#)
- [Feature History and Information for PIM, on page 576](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see [Bug Search Tool](#) and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

## Prerequisites for PIM

- Before you begin the PIM configuration process, decide which PIM mode to use. This is based on the applications you intend to support on your network. Use the following guidelines:
  - In general, if the application is one-to-many or many-to-many in nature, then PIM-SM can be used successfully.
  - For optimal one-to-many application performance, SSM is appropriate but requires IGMP version 3 support.
- Before you configure PIM stub routing, check that you have met these conditions:

- You must have IP multicast routing configured on both the stub router and the central router. You must also have PIM modeconfigured on the uplink interface of the stub router.
- You must also configure either Enhanced Interior Gateway Routing Protocol (EIGRP) stub routing or Open Shortest Path First (OSPF) stub routing on the device.
- The PIM stub router does not route the transit traffic between the distribution routers. Unicast (EIGRP) stub routing enforces this behavior. You must configure unicast stub routing to assist the PIM stub router behavior.

## Restrictions for PIM

The following are the restrictions for configuring PIM:

- PIM is not supported when running the LAN Base feature set.
- Bidirectional PIM is not supported.

## PIMv1 and PIMv2 Interoperability

To avoid misconfiguring multicast routing on your device, review the information in this section.

The Cisco PIMv2 implementation provides interoperability and transition between Version 1 and Version 2, although there might be some minor problems.

You can upgrade to PIMv2 incrementally. PIM Versions 1 and 2 can be configured on different routers and multilayer devices within one network. Internally, all routers and multilayer devices on a shared media network must run the same PIM version. Therefore, if a PIMv2 device detects a PIMv1 device, the Version 2 device downgrades itself to Version 1 until all Version 1 devices have been shut down or upgraded.

PIMv2 uses the BSR to discover and announce RP-set information for each group prefix to all the routers and multilayer devices in a PIM domain. PIMv1, together with the Auto-RP feature, can perform the same tasks as the PIMv2 BSR. However, Auto-RP is a standalone protocol, separate from PIMv1, and is a proprietary Cisco protocol. PIMv2 is a standards track protocol in the IETF.



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**Note** We recommend that you use PIMv2. The BSR function interoperates with Auto-RP on Cisco routers and multilayer devices.

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When PIMv2 devices interoperate with PIMv1 devices, Auto-RP should have already been deployed. A PIMv2 BSR that is also an Auto-RP mapping agent automatically advertises the RP elected by Auto-RP. That is, Auto-RP sets its single RP on every router or multilayer device in the group. Not all routers and devices in the domain use the PIMv2 hash function to select multiple RPs.

Sparse-mode groups in a mixed PIMv1 and PIMv2 region are possible because the Auto-RP feature in PIMv1 interoperates with the PIMv2 RP feature. Although all PIMv2 devices can also use PIMv1, we recommend that the RPs be upgraded to PIMv2. To ease the transition to PIMv2, we recommend:

- Using Auto-RP throughout the region.

If Auto-RP is not already configured in the PIMv1 regions, configure Auto-RP.

**Related Topics**

[PIM Versions](#), on page 521

## Restrictions for Configuring PIM Stub Routing

- The IP services image contains complete multicast routing.
- Only directly connected multicast (IGMP) receivers and sources are allowed in the Layer 2 access domains. The PIM protocol is not supported in access domains.
- In a network using PIM stub routing, the only allowable route for IP traffic to the user is through a device that is configured with PIM stub routing.
- The redundant PIM stub router topology is not supported. Only the nonredundant access router topology is supported by the PIM stub feature.
- PIM stub routing is supported when running the IP Base and IP Services feature sets.

**Related Topics**

[Enabling PIM Stub Routing \(CLI\)](#), on page 534

[PIM Stub Routing](#), on page 521

## Restrictions for Configuring Auto-RP and BSR

Take into consideration your network configuration, and the following restrictions when configuring Auto-RP and BSR:

**Restrictions for Configuring Auto-RP**

The following are restrictions for configuring Auto-RP (if used in your network configuration):

- Auto-RP is not supported when running the LAN Base feature set.
- If routed interfaces are configured in sparse mode, Auto-RP can still be used if all devices are configured with a manual RP address for the Auto-RP groups.
- If routed interfaces are configured in sparse mode and you enter the **ip pim autorp listener** global configuration command, Auto-RP can still be used even if all devices are not configured with a manual RP address for the Auto-RP groups.

**Restrictions for Configuring BSR**

The following are the restrictions for configuring BSR (if used in your network configuration):

- Configure the candidate BSRs as the RP-mapping agents for Auto-RP.
- For group prefixes advertised through Auto-RP, the PIMv2 BSR mechanism should not advertise a subrange of these group prefixes served by a different set of RPs. In a mixed PIMv1 and PIMv2 domain, have backup RPs serve the same group prefixes. This prevents the PIMv2 DRs from selecting a different RP from those PIMv1 DRs, due to the longest match lookup in the RP-mapping database.

### Restrictions and Guidelines for Configuring Auto-RP and BSR

The following are restrictions for configuring Auto-RP and BSR (if used in your network configuration):

- If your network is all Cisco routers and multilayer devices, you can use either Auto-RP or BSR.
- If you have non-Cisco routers in your network, you must use BSR.
- If you have Cisco PIMv1 and PIMv2 routers and multilayer devices and non-Cisco routers, you must use both Auto-RP and BSR. If your network includes routers from other vendors, configure the Auto-RP mapping agent and the BSR on a Cisco PIMv2 device. Ensure that no PIMv1 device is located in the path a between the BSR and a non-Cisco PIMv2 device.



---

**Note** There are two approaches to using PIMv2. You can use Version 2 exclusively in your network or migrate to Version 2 by employing a mixed PIM version environment.

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- Because bootstrap messages are sent hop-by-hop, a PIMv1 device prevents these messages from reaching all routers and multilayer devices in your network. Therefore, if your network has a PIMv1 device in it and only Cisco routers and multilayer devices, it is best to use Auto-RP.
- If you have a network that includes non-Cisco routers, configure the Auto-RP mapping agent and the BSR on a Cisco PIMv2 router or multilayer device. Ensure that no PIMv1 device is on the path between the BSR and a non-Cisco PIMv2 router.
- If you have non-Cisco PIMv2 routers that need to interoperate with Cisco PIMv1 routers and multilayer devices, both Auto-RP and a BSR are required. We recommend that a Cisco PIMv2 device be both the Auto-RP mapping agent and the BSR.

#### Related Topics

- [Setting Up Auto-RP in a New Internetwork \(CLI\)](#), on page 538
- [Auto-RP](#), on page 523
- [Configuring Candidate BSRs \(CLI\)](#), on page 550
- [PIMv2 Bootstrap Router](#), on page 526

## Restrictions for Auto-RP Enhancement

The simultaneous deployment of Auto-RP and bootstrap router (BSR) is not supported.

#### Related Topics

- [Setting Up Auto-RP in a New Internetwork \(CLI\)](#), on page 538
- [Auto-RP](#), on page 523

# Information About PIM

## Protocol Independent Multicast Overview

The Protocol Independent Multicast (PIM) protocol maintains the current IP multicast service mode of receiver-initiated membership. PIM is not dependent on a specific unicast routing protocol; it is IP routing protocol independent and can leverage whichever unicast routing protocols are used to populate the unicast routing table, including Enhanced Interior Gateway Routing Protocol (EIGRP), Open Shortest Path First (OSPF), Border Gateway Protocol (BGP), and static routes. PIM uses unicast routing information to perform the multicast forwarding function.

Although PIM is called a multicast routing protocol, it actually uses the unicast routing table to perform the reverse path forwarding (RPF) check function instead of building up a completely independent multicast routing table. Unlike other routing protocols, PIM does not send and receive routing updates between routers.

PIM is defined in RFC 4601, Protocol Independent Multicast - Sparse Mode (PIM-SM)

For information about PIM forwarding (interface) modes, see the following sections:

### PIM Dense Mode

PIM dense mode (PIM-DM) uses a push model to flood multicast traffic to every corner of the network. This push model is a method for delivering data to the receivers without the receivers requesting the data. This method is efficient in certain deployments in which there are active receivers on every subnet in the network.

In dense mode, a router assumes that all other routers want to forward multicast packets for a group. If a router receives a multicast packet and has no directly connected members or PIM neighbors present, a prune message is sent back to the source. Subsequent multicast packets are not flooded to this router on this pruned branch. PIM builds source-based multicast distribution trees.

PIM-DM initially floods multicast traffic throughout the network. Routers that have no downstream neighbors prune back the unwanted traffic. This process repeats every 3 minutes.

Routers accumulate state information by receiving data streams through the flood and prune mechanism. These data streams contain the source and group information so that downstream routers can build up their multicast forwarding table. PIM-DM supports only source trees--that is, (S,G) entries--and cannot be used to build a shared distribution tree.



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**Note** Dense mode is not often used and its use is not recommended. For this reason it is not specified in the configuration tasks in related modules.

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### PIM Sparse Mode

PIM sparse mode (PIM-SM) uses a pull model to deliver multicast traffic. Only network segments with active receivers that have explicitly requested the data will receive the traffic.

Sparse mode interfaces are added to the multicast routing table only when periodic Join messages are received from downstream routers, or when a directly connected member is on the interface. When forwarding from a LAN, sparse mode operation occurs if an RP is known for the group. If so, the packets are encapsulated and

sent toward the RP. If the multicast traffic from a specific source is sufficient, the first hop router of the receiver may send Join messages toward the source to build a source-based distribution tree.

PIM-SM distributes information about active sources by forwarding data packets on the shared tree. Because PIM-SM uses shared trees (at least, initially), it requires the use of a rendezvous point (RP). The RP must be administratively configured in the network. See the [Rendezvous Points, on page 523](#) section for more information.

In sparse mode, a router assumes that other routers do not want to forward multicast packets for a group, unless there is an explicit request for the traffic. When hosts join a multicast group, the directly connected routers send PIM Join messages toward the RP. The RP keeps track of multicast groups. Hosts that send multicast packets are registered with the RP by the first hop router of that host. The RP then sends Join messages toward the source. At this point, packets are forwarded on a shared distribution tree. If the multicast traffic from a specific source is sufficient, the first hop router of the host may send Join messages toward the source to build a source-based distribution tree.

Sources register with the RP and then data is forwarded down the shared tree to the receivers. The edge routers learn about a particular source when they receive data packets on the shared tree from that source through the RP. The edge router then sends PIM (S,G) Join messages toward that source. Each router along the reverse path compares the unicast routing metric of the RP address to the metric of the source address. If the metric for the source address is better, it will forward a PIM (S,G) Join message toward the source. If the metric for the RP is the same or better, then the PIM (S,G) Join message will be sent in the same direction as the RP. In this case, the shared tree and the source tree would be considered congruent.

If the shared tree is not an optimal path between the source and the receiver, the routers dynamically create a source tree and stop traffic from flowing down the shared tree. This behavior is the default behavior in software. Network administrators can force traffic to stay on the shared tree by using the **ip pim spt-threshold infinity** command.

PIM-SM scales well to a network of any size, including those with WAN links. The explicit join mechanism prevents unwanted traffic from flooding the WAN links.

## Multicast Source Discovery Protocol (MSDP)

Multicast Source Discovery Protocol (MSDP) is used for inter-domain source discovery when PIM SM is used. Each PIM administrative domain has its own RP. In order for the RP in one domain to signal new sources to the RP in the other domain, MSDP is used.

When RP in a domain receives a PIM register message for a new source, with MSDP configured it sends a new source-active (SA) message to all its MSDP peers in other domains. Each intermediate MSDP peer floods this SA message away from the originating RP. The MSDP peers install this SA message in their MSDP sa-cache. If the RPs in other domains have any join requests for the group in the SA message (indicated by the presence of a (\*,G) entry with non empty outgoing interface list), the domain is interested in the group, and the RP triggers an (S,G) join toward the source.

## Sparse-Dense Mode

If you configure either sparse mode or dense mode on an interface, then sparseness or denseness is applied to the interface as a whole. However, some environments might require PIM to run in a single region in sparse mode for some groups and in dense mode for other groups.

An alternative to enabling only dense mode or only sparse mode is to enable sparse-dense mode. In this case, the interface is treated as dense mode if the group is in dense mode; the interface is treated in sparse mode if the group is in sparse mode. You must have an RP if the interface is in sparse-dense mode and you want to treat the group as a sparse group.

If you configure sparse-dense mode, the idea of sparseness or denseness is applied to the groups for which the router is a member.

Another benefit of sparse-dense mode is that Auto-RP information can be distributed in a dense mode; yet, multicast groups for user groups can be used in a sparse mode manner. Therefore there is no need to configure a default RP at the leaf routers.

When an interface is treated in dense mode, it is populated in the outgoing interface list of a multicast routing table when either of the following conditions is true:

- Members or DVMRP neighbors are on the interface.
- There are PIM neighbors and the group has not been pruned.

When an interface is treated in sparse mode, it is populated in the outgoing interface list of a multicast routing table when either of the following conditions is true:

- Members or DVMRP neighbors are on the interface.
- An explicit Join message has been received by a PIM neighbor on the interface.

## PIM Versions

PIMv2 includes these improvements over PIMv1:

- A single, active rendezvous point (RP) exists per multicast group, with multiple backup RPs. This single RP compares to multiple active RPs for the same group in PIMv1.
- A bootstrap router (BSR) provides a fault-tolerant, automated RP discovery and distribution function that enables routers and multilayer devices to dynamically learn the group-to-RP mappings.
- PIM join and prune messages have more flexible encoding for multiple address families.
- A more flexible hello packet format replaces the query packet to encode current and future capability options.
- Register messages sent to an RP specify whether they are sent by a border router or a designated router.
- PIM packets are no longer inside IGMP packets; they are standalone packets.

### Related Topics

[Troubleshooting PIMv1 and PIMv2 Interoperability Problems](#), on page 570

[PIMv1 and PIMv2 Interoperability](#), on page 516

## PIM Stub Routing

The PIM stub routing feature, available in all of the device software images, reduces resource usage by moving routed traffic closer to the end user.

The PIM stub routing feature supports multicast routing between the distribution layer and the access layer. It supports two types of PIM interfaces, uplink PIM interfaces, and PIM passive interfaces. A routed interface configured with the PIM passive mode does not pass or forward PIM control traffic, it only passes and forwards IGMP traffic.

In a network using PIM stub routing, the only allowable route for IP traffic to the user is through a device that is configured with PIM stub routing. PIM passive interfaces are connected to Layer 2 access domains,

such as VLANs, or to interfaces that are connected to other Layer 2 devices. Only directly connected multicast (IGMP) receivers and sources are allowed in the Layer 2 access domains. The PIM passive interfaces do not send or process any received PIM control packets.

When using PIM stub routing, you should configure the distribution and remote routers to use IP multicast routing and configure only the device as a PIM stub router. The device does not route transit traffic between distribution routers. You also need to configure a routed uplink port on the device. The device uplink port cannot be used with SVIs. If you need PIM for an SVI uplink port, you should upgrade to the IP Services feature set.

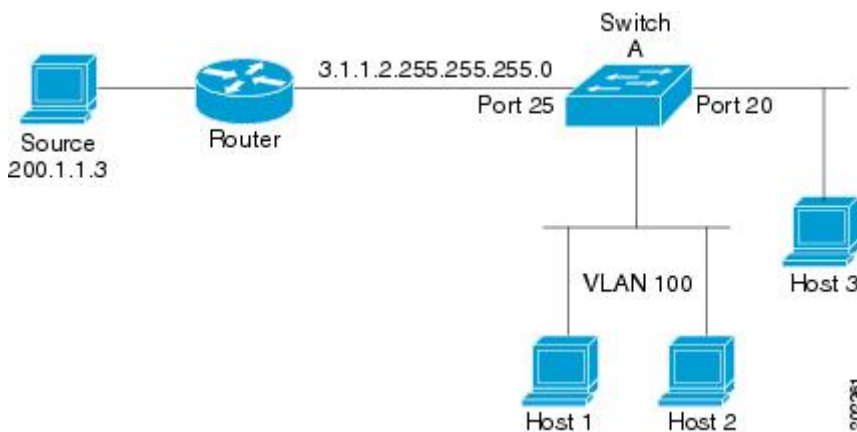


**Note** You must also configure EIGRP stub routing when configuring PIM stub routing on the device

The redundant PIM stub router topology is not supported. The redundant topology exists when there is more than one PIM router forwarding multicast traffic to a single access domain. PIM messages are blocked, and the PIM asset and designated router election mechanisms are not supported on the PIM passive interfaces. Only the nonredundant access router topology is supported by the PIM stub feature. By using a nonredundant topology, the PIM passive interface assumes that it is the only interface and designated router on that access domain.

**Figure 25: PIM Stub Router Configuration**

In the following figure, the Device A routed uplink port 25 is connected to the router and PIM stub routing is enabled on the VLAN 100 interfaces and on Host 3. This configuration allows the directly connected hosts to receive traffic from multicast source 200.1.1.3.



#### Related Topics

- [Enabling PIM Stub Routing \(CLI\), on page 534](#)
- [Example: Enabling PIM Stub Routing, on page 571](#)
- [Example: Verifying PIM Stub Routing, on page 571](#)
- [Restrictions for Configuring PIM Stub Routing, on page 517](#)

## IGMP Helper

PIM stub routing moves routed traffic closer to the end user and reduces network traffic. You can also reduce traffic by configuring a stub router (switch) with the IGMP helper feature.



You can configure a stub router (switch) with the **ip igmp helper-address** *ip-address* interface configuration command to enable the switch to send reports to the next-hop interface. Hosts that are not directly connected to a downstream router can then join a multicast group sourced from an upstream network. The IGMP packets from a host wanting to join a multicast stream are forwarded upstream to the next-hop device when this feature is configured. When the upstream central router receives the helper IGMP reports or leaves, it adds or removes the interfaces from its outgoing interface list for that group.

## Rendezvous Points

A rendezvous point (RP) is a role that a device performs when operating in Protocol Independent Multicast (PIM) Sparse Mode (SM). An RP is required only in networks running PIM SM. In the PIM-SM model, only network segments with active receivers that have explicitly requested multicast data will be forwarded the traffic.

An RP acts as the meeting place for sources and receivers of multicast data. In a PIM-SM network, sources must send their traffic to the RP. This traffic is then forwarded to receivers down a shared distribution tree. By default, when the first hop device of the receiver learns about the source, it will send a Join message directly to the source, creating a source-based distribution tree from the source to the receiver. This source tree does not include the RP unless the RP is located within the shortest path between the source and receiver.

In most cases, the placement of the RP in the network is not a complex decision. By default, the RP is needed only to start new sessions with sources and receivers. Consequently, the RP experiences little overhead from traffic flow or processing. In PIM version 2, the RP performs less processing than in PIM version 1 because sources must only periodically register with the RP to create state.

### Related Topics

[Configuring the Candidate RPs \(CLI\)](#), on page 551

[Configuring a Rendezvous Point](#), on page 536

[Example: Configuring Candidate RPs](#), on page 574

## Auto-RP

In the first version of PIM-SM, all leaf routers (routers directly connected to sources or receivers) were required to be manually configured with the IP address of the RP. This type of configuration is also known as static RP configuration. Configuring static RPs is relatively easy in a small network, but it can be laborious in a large, complex network.

Following the introduction of PIM-SM version 1, Cisco implemented a version of PIM-SM with the Auto-RP feature. Auto-RP automates the distribution of group-to-RP mappings in a PIM network. Auto-RP has the following benefits:

- Configuring the use of multiple RPs within a network to serve different groups is easy.
- Auto-RP allows load splitting among different RPs and arrangement of RPs according to the location of group participants.
- Auto-RP avoids inconsistent, manual RP configurations that can cause connectivity problems.

Multiple RPs can be used to serve different group ranges or serve as backups to each other. For Auto-RP to work, a router must be designated as an RP-mapping agent, which receives the RP-announcement messages from the RPs and arbitrates conflicts. The RP-mapping agent then sends the consistent group-to-RP mappings to all other routers. Thus, all routers automatically discover which RP to use for the groups they support.




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**Note** If router interfaces are configured in sparse mode, Auto-RP can still be used if all routers are configured with a static RP address for the Auto-RP groups.

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To make Auto-RP work, a router must be designated as an RP mapping agent, which receives the RP announcement messages from the RPs and arbitrates conflicts. Thus, all routers automatically discover which RP to use for the groups they support. The Internet Assigned Numbers Authority (IANA) has assigned two group addresses, 224.0.1.39 and 224.0.1.40, for Auto-RP. One advantage of Auto-RP is that any change to the RP designation must be configured only on the routers that are RPs and not on the leaf routers. Another advantage of Auto-RP is that it offers the ability to scope the RP address within a domain. Scoping can be achieved by defining the time-to-live (TTL) value allowed for the Auto-RP advertisements.

Each method for configuring an RP has its own strengths, weaknesses, and level of complexity. In conventional IP multicast network scenarios, we recommend using Auto-RP to configure RPs because it is easy to configure, well-tested, and stable. The alternative ways to configure an RP are static RP, Auto-RP, and bootstrap router.

#### Related Topics

[Setting Up Auto-RP in a New Internetwork \(CLI\)](#), on page 538

[Example: Configuring Auto-RP](#), on page 572

[Example: Sparse Mode with Auto-RP](#), on page 572

[Restrictions for Configuring Auto-RP and BSR](#), on page 517

[Restrictions for Auto-RP Enhancement](#), on page 518

## The Role of Auto-RP in a PIM Network

Auto-RP automates the distribution of group-to-rendezvous point (RP) mappings in a PIM network. To make Auto-RP work, a device must be designated as an RP mapping agent, which receives the RP announcement messages from the RPs and arbitrates conflicts.

Thus, all routers automatically discover which RP to use for the groups they support. The Internet Assigned Numbers Authority (IANA) has assigned two group addresses, 224.0.1.39 and 224.0.1.40, for Auto-RP.

The mapping agent receives announcements of intention to become the RP from Candidate-RPs. The mapping agent then announces the winner of the RP election. This announcement is made independently of the decisions by the other mapping agents.

## Multicast Boundaries

Administratively-scoped boundaries can be used to limit the forwarding of multicast traffic outside of a domain or subdomain. This approach uses a special range of multicast addresses, called administratively-scoped addresses, as the boundary mechanism. If you configure an administratively-scoped boundary on a routed interface, multicast traffic whose multicast group addresses fall in this range cannot enter or exit this interface, which provides a firewall for multicast traffic in this address range.



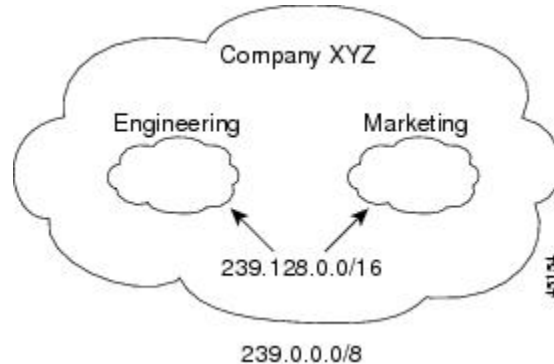

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**Note** Multicast boundaries and TTL thresholds control the scoping of multicast domains; however, TTL thresholds are not supported by the device. You should use multicast boundaries instead of TTL thresholds to limit the forwarding of multicast traffic outside of a domain or a subdomain.

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**Figure 26: Administratively-Scoped Boundaries**

The following figure shows that Company XYZ has an administratively-scoped boundary set for the multicast address range 239.0.0.0/8 on all routed interfaces at the perimeter of its network. This boundary prevents any multicast traffic in the range 239.0.0.0 through 239.255.255.255 from entering or leaving the network. Similarly, the engineering and marketing departments have an administratively-scoped boundary of 239.128.0.0/16 around the perimeter of their networks. This boundary prevents multicast traffic in the range of 239.128.0.0 through 239.128.255.255 from entering or leaving their respective networks.



You can define an administratively-scoped boundary on a routed interface for multicast group addresses. A standard access list defines the range of addresses affected. When a boundary is defined, no multicast data packets are allowed to flow across the boundary from either direction. The boundary allows the same multicast group address to be reused in different administrative domains.

The IANA has designated the multicast address range 239.0.0.0 to 239.255.255.255 as the administratively-scoped addresses. This range of addresses can then be reused in domains administered by different organizations. The addresses would be considered local, not globally unique.

You can configure the **filter-autorp** keyword to examine and filter Auto-RP discovery and announcement messages at the administratively scoped boundary. Any Auto-RP group range announcements from the Auto-RP packets that are denied by the boundary access control list (ACL) are removed. An Auto-RP group range announcement is permitted and passed by the boundary only if all addresses in the Auto-RP group range are permitted by the boundary ACL. If any address is not permitted, the entire group range is filtered and removed from the Auto-RP message before the Auto-RP message is forwarded.

### Related Topics

[Defining the IP Multicast Boundary \(CLI\)](#), on page 548

[Example: Defining the IP Multicast Boundary to Deny Auto-RP Information](#), on page 572

## Sparse-Dense Mode for Auto-RP

A prerequisite of Auto-RP is that all interfaces must be configured in sparse-dense mode using the **ip pim sparse-dense-mode** interface configuration command. An interface configured in sparse-dense mode is treated in either sparse mode or dense mode of operation, depending on which mode the multicast group operates. If a multicast group has a known RP, the interface is treated in sparse mode. If a group has no known RP, by default the interface is treated in dense mode and data will be flooded over this interface. (You can prevent dense-mode fallback; see the module “Configuring Basic IP Multicast.”)

To successfully implement Auto-RP and prevent any groups other than 224.0.1.39 and 224.0.1.40 from operating in dense mode, we recommend configuring a “sink RP” (also known as “RP of last resort”). A sink RP is a statically configured RP that may or may not actually exist in the network. Configuring a sink RP does not interfere with Auto-RP operation because, by default, Auto-RP messages supersede static RP

configurations. We recommend configuring a sink RP for all possible multicast groups in your network, because it is possible for an unknown or unexpected source to become active. If no RP is configured to limit source registration, the group may revert to dense mode operation and be flooded with data.

### Related Topics

[Adding Auto-RP to an Existing Sparse-Mode Cloud \(CLI\)](#), on page 541

## Auto-RP Benefits

Auto-RP uses IP multicast to automate the distribution of group-to-RP mappings to all Cisco routers and multilayer devices in a PIM network. Auto-RP has these benefits:

- Easy to use multiple RPs within a network to serve different group ranges.
- Provides load splitting among different RPs and arrangement of RPs according to the location of group participants.
- Avoids inconsistent, manual RP configurations on every router and multilayer device in a PIM network, which can cause connectivity problems.

### Benefits of Auto-RP in a PIM Network

- Auto-RP allows any change to the RP designation to be configured only on the devices that are RPs, not on the leaf routers.
- Auto-RP offers the ability to scope the RP address within a domain.

## PIMv2 Bootstrap Router

PIMv2 Bootstrap Router (BSR) is another method to distribute group-to-RP mapping information to all PIM routers and multilayer devices in the network. It eliminates the need to manually configure RP information in every router and device in the network. However, instead of using IP multicast to distribute group-to-RP mapping information, BSR uses hop-by-hop flooding of special BSR messages to distribute the mapping information.

The BSR is elected from a set of candidate routers and devices in the domain that have been configured to function as BSRs. The election mechanism is similar to the root-bridge election mechanism used in bridged LANs. The BSR election is based on the BSR priority of the device contained in the BSR messages that are sent hop-by-hop through the network. Each BSR device examines the message and forwards out all interfaces only the message that has either a higher BSR priority than its BSR priority or the same BSR priority, but with a higher BSR IP address. Using this method, the BSR is elected.

The elected BSR sends BSR messages with a TTL of 1. Neighboring PIMv2 routers or multilayer devices receive the BSR message and multicast it out all other interfaces (except the one on which it was received) with a TTL of 1. In this way, BSR messages travel hop-by-hop throughout the PIM domain. Because BSR messages contain the IP address of the current BSR, the flooding mechanism enables candidate RPs to automatically learn which device is the elected BSR.

Candidate RPs send candidate RP advertisements showing the group range for which they are responsible to the BSR, which stores this information in its local candidate-RP cache. The BSR periodically advertises the contents of this cache in BSR messages to all other PIM devices in the domain. These messages travel hop-by-hop through the network to all routers and devices, which store the RP information in the BSR message in their local RP cache. The routers and devices select the same RP for a given group because they all use a common RP hashing algorithm.

**Related Topics**

[Configuring Candidate BSRs \(CLI\)](#), on page 550

[Configuring PIMv2 BSR](#), on page 546

[Example: Configuring Candidate BSRs](#), on page 573

[Restrictions for Configuring Auto-RP and BSR](#), on page 517

**PIM Domain Border**

As IP multicast becomes more widespread, the chance of one PIMv2 domain bordering another PIMv2 domain increases. Because two domains probably do not share the same set of RPs, BSR, candidate RPs, and candidate BSRs, you need to constrain PIMv2 BSR messages from flowing into or out of the domain. Allowing messages to leak across the domain borders could adversely affect the normal BSR election mechanism and elect a single BSR across all bordering domains and comingle candidate RP advertisements, resulting in the election of RPs in the wrong domain.

**Related Topics**

[Defining the PIM Domain Border \(CLI\)](#), on page 546

**Multicast Forwarding**

Forwarding of multicast traffic is accomplished by multicast-capable routers. These routers create distribution trees that control the path that IP multicast traffic takes through the network in order to deliver traffic to all receivers.

Multicast traffic flows from the source to the multicast group over a distribution tree that connects all of the sources to all of the receivers in the group. This tree may be shared by all sources (a shared tree) or a separate distribution tree can be built for each source (a source tree). The shared tree may be one-way or bidirectional.

Before describing the structure of source and shared trees, it is helpful to explain the notations that are used in multicast routing tables. These notations include the following:

- (S,G) = (unicast source for the multicast group G, multicast group G)
- (\*,G) = (any source for the multicast group G, multicast group G)

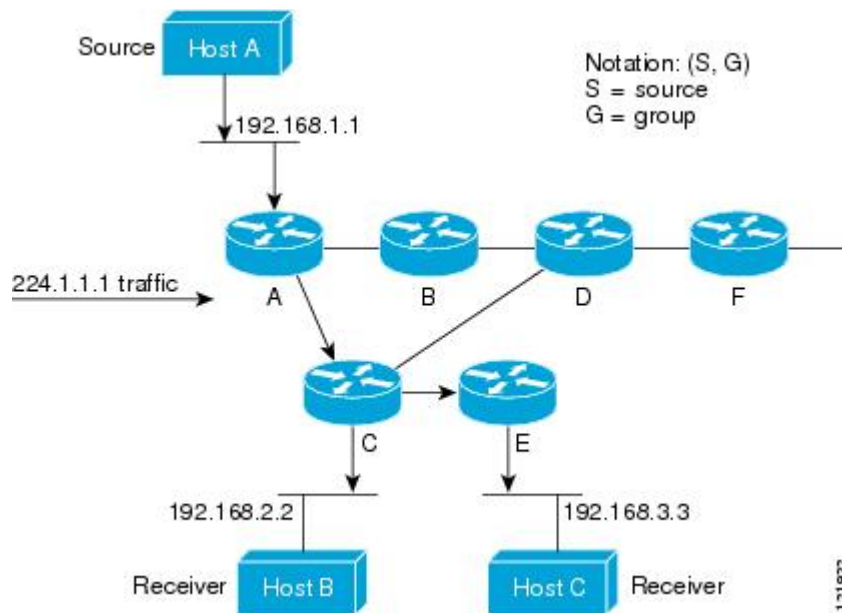
The notation of (S,G), pronounced “S comma G,” enumerates a shortest path tree where S is the IP address of the source and G is the multicast group address.

Shared trees are (\*,G) and the source trees are (S,G) and always routed at the sources.

**Multicast Distribution Source Tree**

The simplest form of a multicast distribution tree is a source tree. A source tree has its root at the source host and has branches forming a spanning tree through the network to the receivers. Because this tree uses the shortest path through the network, it is also referred to as a shortest path tree (SPT).

The figure shows an example of an SPT for group 224.1.1.1 rooted at the source, Host A, and connecting two receivers, Hosts B and C.



Using standard notation, the SPT for the example shown in the figure would be (192.168.1.1, 224.1.1.1).

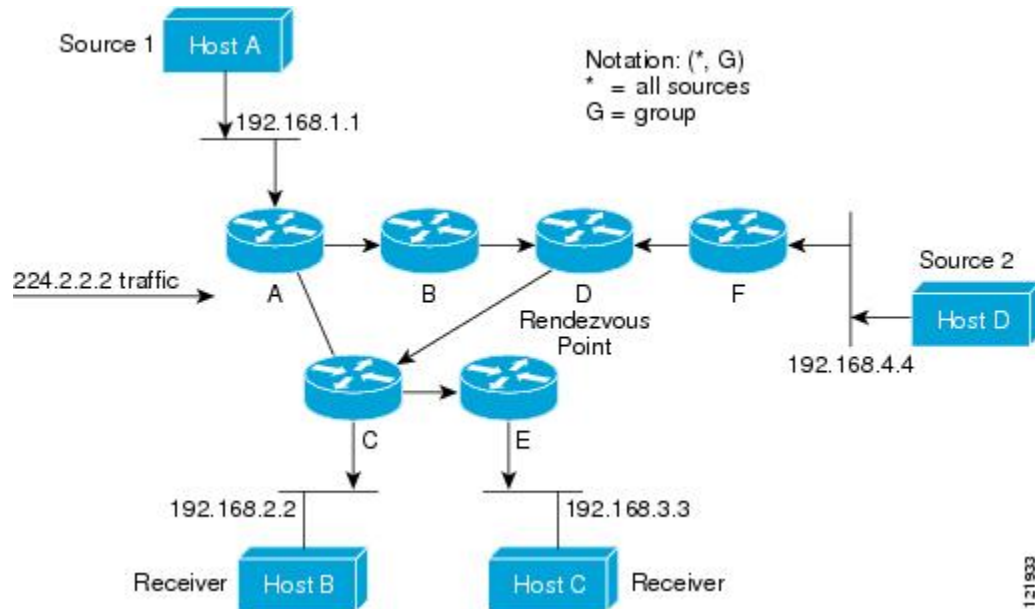
The (S,G) notation implies that a separate SPT exists for each individual source sending to each group--which is correct.

## Multicast Distribution Shared Tree

Unlike source trees that have their root at the source, shared trees use a single common root placed at some chosen point in the network. This shared root is called a rendezvous point (RP).

The following figure shows a shared tree for the group 224.2.2.2 with the root located at Router D. This shared tree is unidirectional. Source traffic is sent towards the RP on a source tree. The traffic is then forwarded down the shared tree from the RP to reach all of the receivers (unless the receiver is located between the source and the RP, in which case it will be serviced directly).

Figure 27: Shared Tree



In this example, multicast traffic from the sources, Hosts A and D, travels to the root (Router D) and then down the shared tree to the two receivers, Hosts B and C. Because all sources in the multicast group use a common shared tree, a wildcard notation written as (\*, G), pronounced “star comma G,” represents the tree. In this case, \* means all sources, and G represents the multicast group. Therefore, the shared tree shown in the figure would be written as (\*, 224.2.2.2).

Both source trees and shared trees are loop-free. Messages are replicated only where the tree branches. Members of multicast groups can join or leave at any time; therefore the distribution trees must be dynamically updated. When all the active receivers on a particular branch stop requesting the traffic for a particular multicast group, the routers prune that branch from the distribution tree and stop forwarding traffic down that branch. If one receiver on that branch becomes active and requests the multicast traffic, the router will dynamically modify the distribution tree and start forwarding traffic again.

## Source Tree Advantage

Source trees have the advantage of creating the optimal path between the source and the receivers. This advantage guarantees the minimum amount of network latency for forwarding multicast traffic. However, this optimization comes at a cost. The routers must maintain path information for each source. In a network that has thousands of sources and thousands of groups, this overhead can quickly become a resource issue on the routers. Memory consumption from the size of the multicast routing table is a factor that network designers must take into consideration.

## Shared Tree Advantage

Shared trees have the advantage of requiring the minimum amount of state in each router. This advantage lowers the overall memory requirements for a network that only allows shared trees. The disadvantage of shared trees is that under certain circumstances the paths between the source and receivers might not be the optimal paths, which might introduce some latency in packet delivery. For example, in the figure above the shortest path between Host A (source 1) and Host B (a receiver) would be Router A and Router C. Because we are using Router D as the root for a shared tree, the traffic must traverse Routers A, B, D and then C.

Network designers must carefully consider the placement of the rendezvous point (RP) when implementing a shared tree-only environment.

In unicast routing, traffic is routed through the network along a single path from the source to the destination host. A unicast router does not consider the source address; it considers only the destination address and how to forward the traffic toward that destination. The router scans through its routing table for the destination address and then forwards a single copy of the unicast packet out the correct interface in the direction of the destination.

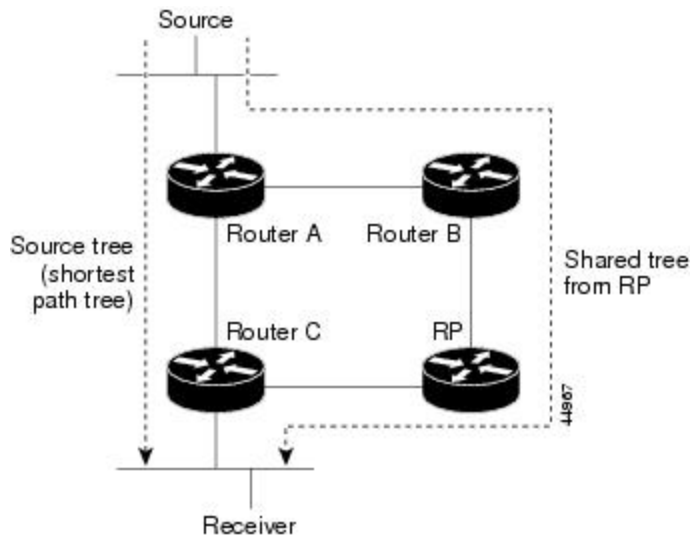
In multicast forwarding, the source is sending traffic to an arbitrary group of hosts that are represented by a multicast group address. The multicast router must determine which direction is the upstream direction (toward the source) and which one is the downstream direction (or directions) toward the receivers. If there are multiple downstream paths, the router replicates the packet and forwards it down the appropriate downstream paths (best unicast route metric)--which is not necessarily all paths. Forwarding multicast traffic away from the source, rather than to the receiver, is called Reverse Path Forwarding (RPF). RPF is described in the following section.

## PIM Shared Tree and Source Tree

By default, members of a group receive data from senders to the group across a single data-distribution tree rooted at the RP.

**Figure 28: Shared Tree and Source Tree (Shortest-Path Tree)**

The following figure shows this type of shared-distribution tree. Data from senders is delivered to the RP for distribution to group members joined to the shared tree.



If the data rate warrants, leaf routers (routers without any downstream connections) on the shared tree can use the data distribution tree rooted at the source. This type of distribution tree is called a shortest-path tree or source tree. By default, the software devices to a source tree upon receiving the first data packet from a source.

This process describes the move from a shared tree to a source tree:

1. A receiver joins a group; leaf Router C sends a join message toward the RP.
2. The RP puts a link to Router C in its outgoing interface list.
3. A source sends data; Router A encapsulates the data in a register message and sends it to the RP.



4. The RP forwards the data down the shared tree to Router C and sends a join message toward the source. At this point, data might arrive twice at Router C, once encapsulated and once natively.
5. When data arrives natively (unencapsulated) at the RP, it sends a register-stop message to Router A.
6. By default, reception of the first data packet prompts Router C to send a join message toward the source.
7. When Router C receives data on (S, G), it sends a prune message for the source up the shared tree.
8. The RP deletes the link to Router C from the outgoing interface of (S, G). The RP triggers a prune message toward the source.

Join and prune messages are sent for sources and RPs. They are sent hop-by-hop and are processed by each PIM device along the path to the source or RP. Register and register-stop messages are not sent hop-by-hop. They are sent by the designated router that is directly connected to a source and are received by the RP for the group.

Multiple sources sending to groups use the shared tree. You can configure the PIM device to stay on the shared tree.

The change from shared to source tree happens when the first data packet arrives at the last-hop router. This change depends upon the threshold that is configured by using the **ip pim spt-threshold** global configuration command.

The shortest-path tree requires more memory than the shared tree but reduces delay. You may want to postpone its use. Instead of allowing the leaf router to immediately move to the shortest-path tree, you can specify that the traffic must first reach a threshold.

You can configure when a PIM leaf router should join the shortest-path tree for a specified group. If a source sends at a rate greater than or equal to the specified kbps rate, the multilayer switch triggers a PIM join message toward the source to construct a source tree (shortest-path tree). If the traffic rate from the source drops below the threshold value, the leaf router switches back to the shared tree and sends a prune message toward the source.

You can specify to which groups the shortest-path tree threshold applies by using a group list (a standard access list). If a value of 0 is specified or if the group list is not used, the threshold applies to all groups.

### Related Topics

[Delaying the Use of PIM Shortest-Path Tree \(CLI\)](#), on page 557

## Reverse Path Forwarding

In unicast routing, traffic is routed through the network along a single path from the source to the destination host. A unicast router does not consider the source address; it considers only the destination address and how to forward the traffic toward that destination. The router scans through its routing table for the destination network and then forwards a single copy of the unicast packet out the correct interface in the direction of the destination.

In multicast forwarding, the source is sending traffic to an arbitrary group of hosts that are represented by a multicast group address. The multicast router must determine which direction is the upstream direction (toward the source) and which one is the downstream direction (or directions) toward the receivers. If there are multiple downstream paths, the router replicates the packet and forwards it down the appropriate downstream paths (best unicast route metric)—which is not necessarily all paths. Forwarding multicast traffic away from the source, rather than to the receiver, is called Reverse Path Forwarding (RPF). RPF is an algorithm used for forwarding multicast datagrams.

Protocol Independent Multicast (PIM) uses the unicast routing information to create a distribution tree along the reverse path from the receivers towards the source. The multicast routers then forward packets along the distribution tree from the source to the receivers. RPF is a key concept in multicast forwarding. It enables routers to correctly forward multicast traffic down the distribution tree. RPF makes use of the existing unicast routing table to determine the upstream and downstream neighbors. A router will forward a multicast packet only if it is received on the upstream interface. This RPF check helps to guarantee that the distribution tree will be loop-free.

## RPF Check

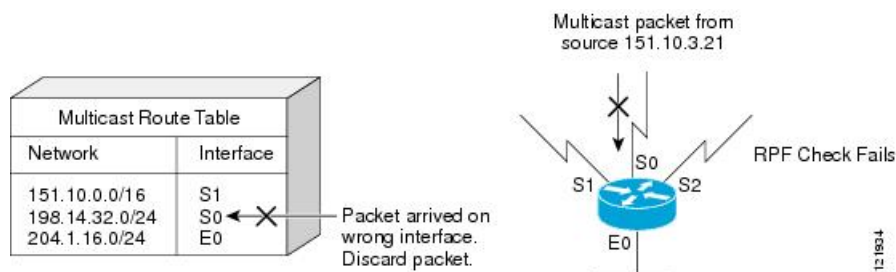
When a multicast packet arrives at a router, the router performs an RPF check on the packet. If the RPF check succeeds, the packet is forwarded. Otherwise, it is dropped.

For traffic flowing down a source tree, the RPF check procedure works as follows:

1. The router looks up the source address in the unicast routing table to determine if the packet has arrived on the interface that is on the reverse path back to the source.
2. If the packet has arrived on the interface leading back to the source, the RPF check succeeds and the packet is forwarded out the interfaces present in the outgoing interface list of a multicast routing table entry.
3. If the RPF check in Step 2 fails, the packet is dropped.

The figure shows an example of an unsuccessful RPF check.

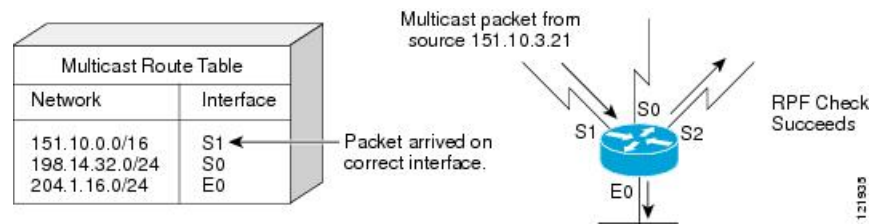
**Figure 29: RPF Check Fails**



As the figure illustrates, a multicast packet from source 151.10.3.21 is received on serial interface 0 (S0). A check of the unicast route table shows that S1 is the interface this router would use to forward unicast data to 151.10.3.21. Because the packet has arrived on interface S0, the packet is discarded.

The figure shows an example of a successful RPF check.

Figure 30: RPF Check Succeeds



In this example, the multicast packet has arrived on interface S1. The router refers to the unicast routing table and finds that S1 is the correct interface. The RPF check passes, and the packet is forwarded.

PIM uses both source trees and RP-rooted shared trees to forward datagrams. The RPF check is performed differently for each:

- If a PIM router or multilayer device has a source-tree state (that is, an (S, G) entry is present in the multicast routing table), it performs the RPF check against the IP address of the source of the multicast packet.
- If a PIM router or multilayer device has a shared-tree state (and no explicit source-tree state), it performs the RPF check on the RP address (which is known when members join the group).



**Note** DVMRP is not supported on the device.

Sparse-mode PIM uses the RPF lookup function to decide where it needs to send joins and prunes:

- (S, G) joins (which are source-tree states) are sent toward the source.
- (\*,G) joins (which are shared-tree states) are sent toward the RP.

## Default PIM Routing Configuration

This table displays the default PIM routing configuration for the device.

Table 42: Default Multicast Routing Configuration

Feature	Default Setting
Multicast routing	Disabled on all interfaces.
PIM version	Version 2.
PIM mode	No mode is defined.
PIM stub routing	None configured.
PIM RP address	None configured.
PIM domain border	Disabled.
PIM multicast boundary	None.

Feature	Default Setting
Candidate BSRs	Disabled.
Candidate RPs	Disabled.
Shortest-path tree threshold rate	0 kb/s.
PIM router query message interval	30 seconds.

## How to Configure PIM

### Enabling PIM Stub Routing (CLI)

This procedure is optional.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface</b> <b>gigabitethernet 1/0/1</b>	Specifies the interface on which you want to enable PIM stub routing, and enters interface configuration mode.  The specified interface must be one of the following: <ul style="list-style-type: none"> <li>• A routed port—A physical port that has been configured as a Layer 3 port by entering the <b>no switchport</b> interface configuration command.</li> <li>• An SVI—A VLAN interface created by using the <b>interface vlan <i>vlan-id</i></b> global configuration command.</li> </ul> These interfaces must have IP addresses assigned to them.

	Command or Action	Purpose
<b>Step 4</b>	<b>ip pim passive</b> <b>Example:</b>  Device(config-if)# <b>ip pim passive</b>	Configures the PIM stub feature on the interface.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show ip pim interface</b> <b>Example:</b>  Device# <b>show ip pim interface</b>	(Optional) Displays the PIM stub that is enabled on each interface.
<b>Step 7</b>	<b>show ip igmp groups detail</b> <b>Example:</b>  Device# <b>show ip igmp groups detail</b>	(Optional) Displays the interested clients that have joined the specific multicast source group.
<b>Step 8</b>	<b>show ip mroute</b> <b>Example:</b>  Device# <b>show ip mroute</b>	(Optional) Displays the IP multicast routing table.
<b>Step 9</b>	<b>show running-config</b> <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 10</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[PIM Stub Routing](#), on page 521

[Example: Enabling PIM Stub Routing](#), on page 571

[Example: Verifying PIM Stub Routing](#), on page 571

[Restrictions for Configuring PIM Stub Routing](#), on page 517

## Configuring a Rendezvous Point

You must have a rendezvous point (RP), if the interface is in sparse-dense mode and if you want to handle the group as a sparse group. You can use these methods:

- By manually assigning an RP to multicast groups.
- As a standalone, Cisco-proprietary protocol separate from PIMv1, which includes:
  - Setting up Auto-RP in a new internetwork
  - Adding Auto-RP to an existing sparse-mode cloud
  - Preventing join messages to false RPs
  - Filtering incoming RP announcement messages
- By using a standards track protocol in the Internet Engineering Task Force (IETF), which includes configuring PIMv2 BSR .



**Note** You can use Auto-RP, BSR, or a combination of both, depending on the PIM version that you are running and the types of routers in your network. For information about working with different PIM versions in your network, see [PIMv1 and PIMv2 Interoperability, on page 516](#).

### Related Topics

[Configuring the Candidate RPs \(CLI\), on page 551](#)

[Rendezvous Points, on page 523](#)

## Manually Assigning an RP to Multicast Groups (CLI)

If the rendezvous point (RP) for a group is learned through a dynamic mechanism (such as Auto-RP or BSR), you need not perform this task for that RP.

Senders of multicast traffic announce their existence through register messages received from the source first-hop router (designated router) and forwarded to the RP. Receivers of multicast packets use RPs to join a multicast group by using explicit join messages.



**Note** RPs are not members of the multicast group; they serve as a *meeting place* for multicast sources and group members.

You can configure a single RP for multiple groups defined by an access list. If there is no RP configured for a group, the multilayer device responds to the group as dense and uses the dense-mode PIM techniques.

This procedure is optional.

### Procedure

	Command or Action	Purpose
Step 1	enable	Enables privileged EXEC mode.

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<p><b>ip pim rp-address <i>ip-address</i> [<i>access-list-number</i>] [<i>override</i>]</b></p> <p><b>Example:</b></p> <pre>Device(config)# ip pim rp-address 10.1.1.1 20 override</pre>	<p>Configures the address of a PIM RP.</p> <p>By default, no PIM RP address is configured. You must configure the IP address of RPs on all routers and multilayer devices (including the RP).</p> <p><b>Note</b> If there is no RP configured for a group, the device treats the group as dense, using the dense-mode PIM techniques.</p> <p>A PIM device can be an RP for more than one group. Only one RP address can be used at a time within a PIM domain. The access list conditions specify for which groups the device is an RP.</p> <ul style="list-style-type: none"> <li>• For <i>ip-address</i>, enter the unicast address of the RP in dotted-decimal notation.</li> <li>• (Optional) For <i>access-list-number</i>, enter an IP standard access list number from 1 to 99. If no access list is configured, the RP is used for all groups.</li> <li>• (Optional) The <b>override</b> keyword indicates that if there is a conflict between the RP configured with this command and one learned by Auto-RP or BSR, the RP configured with this command prevails.</li> </ul>
<b>Step 4</b>	<p><b>access-list <i>access-list-number</i> {deny   permit} <i>source</i> [<i>source-wildcard</i>]</b></p> <p><b>Example:</b></p> <pre>Device(config)# access-list 25 permit 10.5.0.1 255.224.0.0</pre>	<p>Creates a standard access list, repeating the command as many times as necessary.</p> <ul style="list-style-type: none"> <li>• For <i>access-list-number</i>, enter the access list number specified in Step 2.</li> <li>• The <b>deny</b> keyword denies access if the conditions are matched.</li> <li>• The <b>permit</b> keyword permits access if the conditions are matched.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>For <i>source</i>, enter the multicast group address for which the RP should be used.</li> <li>(Optional) For <i>source-wildcard</i>, enter the wildcard bits in dotted decimal notation to be applied to the source. Place ones in the bit positions that you want to ignore.</li> </ul> <p>The access list is always terminated by an implicit deny statement for everything.</p>
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Example: Manually Assigning an RP to Multicast Groups](#), on page 572

**Setting Up Auto-RP in a New Internetwork (CLI)**

**Note** Omit Step 3 in the following procedure, if you want to configure a PIM router as the RP for the local group.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>



	Command or Action	Purpose
Step 2	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	<p>Verifies that a default RP is already configured on all PIM devices and the RP in the sparse-mode network. It was previously configured with the <b>ip pim rp-address</b> global configuration command.</p> <p><b>Note</b> This step is not required for spare-dense-mode environments.</p> <p>The selected RP should have good connectivity and be available across the network. Use this RP for the global groups (for example, 224.x.x.x and other global groups). Do not reconfigure the group address range that this RP serves. RPs dynamically discovered through Auto-RP take precedence over statically configured RPs. Assume that it is desirable to use a second RP for the local groups.</p>
Step 3	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	<p>Enters global configuration mode.</p>
Step 4	<p><b>ip pim send-rp-announce</b> <i>interface-id</i> <b>scope</b> <i>tvl</i> <b>group-list</b> <i>access-list-number</i> <b>interval</b> <i>seconds</i></p> <p><b>Example:</b></p> <pre>Device(config)# ip pim send-rp-announce gigabitethernet 1/0/5 scope 20 group-list 10 interval 120</pre>	<p>Configures another PIM device to be the candidate RP for local groups.</p> <ul style="list-style-type: none"> <li>For <i>interface-id</i>, enter the interface type and number that identifies the RP address. Valid interfaces include physical ports, port channels, and VLANs.</li> <li>For <b>scope</b> <i>tvl</i>, specify the time-to-live value in hops. Enter a hop count that is high enough so that the RP-announce messages reach all mapping agents in the network. There is no default setting. The range is 1 to 255.</li> <li>For <b>group-list</b> <i>access-list-number</i>, enter an IP standard access list number from 1 to 99. If no access list is configured, the RP is used for all groups.</li> <li>For <b>interval</b> <i>seconds</i>, specify how often the announcement messages must be sent. The default is 60 seconds. The range is 1 to 16383.</li> </ul>

	Command or Action	Purpose
<b>Step 5</b>	<p><b>access-list</b> <i>access-list-number</i> {<b>deny</b>   <b>permit</b>} <i>source</i> [<i>source-wildcard</i>]</p> <p><b>Example:</b></p> <pre>Device(config)# <b>access-list</b> 10 <b>permit</b> 10.10.0.0</pre>	<p>Creates a standard access list, repeating the command as many times as necessary.</p> <ul style="list-style-type: none"> <li>For <i>access-list-number</i>, enter the access list number specified in Step 3.</li> <li>The <b>deny</b> keyword denies access if the conditions are matched.</li> <li>The <b>permit</b> keyword permits access if the conditions are matched.</li> <li>For <i>source</i>, enter the multicast group address range for which the RP should be used.</li> <li>(Optional) For <i>source-wildcard</i>, enter the wildcard bits in dotted decimal notation to be applied to the source. Place ones in the bit positions that you want to ignore.</li> </ul> <p><b>Note</b> Recall that the access list is always terminated by an implicit deny statement for everything.</p>
<b>Step 6</b>	<p><b>ip pim send-rp-discovery scope</b> <i>tll</i></p> <p><b>Example:</b></p> <pre>Device(config)# <b>ip pim send-rp-discovery</b> <b>scope</b> 50</pre>	<p>Finds a device whose connectivity is not likely to be interrupted, and assign it the role of RP-mapping agent.</p> <p>For <b>scope</b> <i>tll</i>, specify the time-to-live value in hops to limit the RP discovery packets. All devices within the hop count from the source device receive the Auto-RP discovery messages. These messages tell other devices which group-to-RP mapping to use to avoid conflicts (such as overlapping group-to-RP ranges). There is no default setting. The range is 1 to 255.</p>
<b>Step 7</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# <b>end</b></pre>	<p>Returns to privileged EXEC mode.</p>
<b>Step 8</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# <b>show running-config</b></pre>	<p>Verifies your entries.</p>

	Command or Action	Purpose
<b>Step 9</b>	<b>show ip pim rp mapping</b> <b>Example:</b> Device# <code>show ip pim rp mapping</code>	Displays active RPs that are cached with associated multicast routing entries.
<b>Step 10</b>	<b>show ip pim rp</b> <b>Example:</b> Device# <code>show ip pim rp</code>	Displays the information cached in the routing table.
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

#### Related Topics

[Auto-RP](#), on page 523

[Example: Configuring Auto-RP](#), on page 572

[Example: Sparse Mode with Auto-RP](#), on page 572

[Restrictions for Configuring Auto-RP and BSR](#), on page 517

[Restrictions for Auto-RP Enhancement](#), on page 518

## Adding Auto-RP to an Existing Sparse-Mode Cloud (CLI)

This section contains suggestions for the initial deployment of Auto-RP into an existing sparse-mode cloud to minimize disruption of the existing multicast infrastructure.

This procedure is optional.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>show running-config</b> <b>Example:</b> Device# <code>show running-config</code>	Verifies that a default RP is already configured on all PIM devices and the RP in the sparse-mode network. It was previously configured with the <b>ip pim rp-address</b> global configuration command.

	Command or Action	Purpose
		<p><b>Note</b> This step is not required for sparse-dense-mode environments.</p> <p>The selected RP should have good connectivity and be available across the network. Use this RP for the global groups (for example, 224.x.x.x and other global groups). Do not reconfigure the group address range that this RP serves. RPs dynamically discovered through Auto-RP take precedence over statically configured RPs. Assume that it is desirable to use a second RP for the local groups.</p>
<b>Step 3</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 4</b>	<p><b>ip pim send-rp-announce</b> <i>interface-id</i> <b>scope</b> <i>ttl</i> <b>group-list</b> <i>access-list-number</i> <b>interval</b> <i>seconds</i></p> <p><b>Example:</b></p> <pre>Device (config)# ip pim send-rp-announce gigabitethernet 1/0/5 scope 20 group-list 10 interval 120</pre>	<p>Configures another PIM device to be the candidate RP for local groups.</p> <ul style="list-style-type: none"> <li>For <i>interface-id</i>, enter the interface type and number that identifies the RP address. Valid interfaces include physical ports, port channels, and VLANs.</li> <li>For <b>scope</b> <i>ttl</i>, specify the time-to-live value in hops. Enter a hop count that is high enough so that the RP-announce messages reach all mapping agents in the network. There is no default setting. The range is 1 to 255.</li> <li>For <b>group-list</b> <i>access-list-number</i>, enter an IP standard access list number from 1 to 99. If no access list is configured, the RP is used for all groups.</li> <li>For <b>interval</b> <i>seconds</i>, specify how often the announcement messages must be sent. The default is 60 seconds. The range is 1 to 16383.</li> </ul>
<b>Step 5</b>	<p><b>access-list</b> <i>access-list-number</i> {<b>deny</b>   <b>permit</b>} <i>source</i> [<i>source-wildcard</i>]</p> <p><b>Example:</b></p> <pre>Device (config)# access-list 10</pre>	<p>Creates a standard access list, repeating the command as many times as necessary.</p> <ul style="list-style-type: none"> <li>For <i>access-list-number</i>, enter the access list number specified in Step 3.</li> </ul>

	Command or Action	Purpose
	<code>permit 224.0.0.0 15.255.255.255</code>	<ul style="list-style-type: none"> <li>The <b>deny</b> keyword denies access if the conditions are matched.</li> <li>The <b>permit</b> keyword permits access if the conditions are matched.</li> <li>For <i>source</i>, enter the multicast group address range for which the RP should be used.</li> <li>(Optional) For <i>source-wildcard</i>, enter the wildcard bits in dotted decimal notation to be applied to the source. Place ones in the bit positions that you want to ignore.</li> </ul> <p>Recall that the access list is always terminated by an implicit deny statement for everything.</p>
<b>Step 6</b>	<p><b>ip pim send-rp-discovery scope ttl</b></p> <p><b>Example:</b></p> <pre>Device(config)# ip pim send-rp-discovery scope 50</pre>	<p>Finds a device whose connectivity is not likely to be interrupted, and assigns it the role of RP-mapping agent.</p> <p>For <b>scope ttl</b>, specify the time-to-live value in hops to limit the RP discovery packets. All devices within the hop count from the source device receive the Auto-RP discovery messages. These messages tell other devices which group-to-RP mapping to use to avoid conflicts (such as overlapping group-to-RP ranges). There is no default setting. The range is 1 to 255.</p> <p><b>Note</b> To remove the device as the RP-mapping agent, use the <b>no ip pim send-rp-discovery</b> global configuration command.</p>
<b>Step 7</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 8</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 9</b>	<p><b>show ip pim rp mapping</b></p> <p><b>Example:</b></p>	Displays active RPs that are cached with associated multicast routing entries.

	Command or Action	Purpose
	Device# <code>show ip pim rp mapping</code>	
<b>Step 10</b>	<b>show ip pim rp</b> <b>Example:</b>  Device# <code>show ip pim rp</code>	Displays the information cached in the routing table.
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Sparse-Dense Mode for Auto-RP](#), on page 525

**Preventing Join Messages to False RPs (CLI)**

Determine whether the `ip pim accept-rp` command was previously configured throughout the network by using the `show running-config` privileged EXEC command. If the `ip pim accept-rp` command is not configured on any device, this problem can be addressed later. In those routers or multilayer devices already configured with the `ip pim accept-rp` command, you must enter the command again to accept the newly advertised RP.

To accept all RPs advertised with Auto-RP and reject all other RPs by default, use the `ip pim accept-rp auto-rp` global configuration command.

This procedure is optional.

**Related Topics**

[Example: Preventing Join Messages to False RPs](#), on page 573

**Filtering Incoming RP Announcement Messages (CLI)**

You can add configuration commands to the mapping agents to prevent a maliciously configured router from masquerading as a candidate RP and causing problems.

This procedure is optional.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<p><b>ip pim rp-announce-filter rp-list access-list-number group-list access-list-number</b></p> <p><b>Example:</b></p> <pre>Device(config)# ip pim rp-announce-filter rp-list 10 group-list 14</pre>	<p>Filters incoming RP announcement messages.</p> <p>Enter this command on each mapping agent in the network. Without this command, all incoming RP-announce messages are accepted by default.</p> <p>For <b>rp-list access-list-number</b>, configure an access list of candidate RP addresses that, if permitted, is accepted for the group ranges supplied in the <b>group-list access-list-number</b> variable. If this variable is omitted, the filter applies to all multicast groups.</p> <p>If more than one mapping agent is used, the filters must be consistent across all mapping agents to ensure that no conflicts occur in the group-to-RP mapping information.</p>
<b>Step 4</b>	<p><b>access-list access-list-number {deny   permit} source [source-wildcard]</b></p> <p><b>Example:</b></p> <pre>Device(config)# access-list 10 permit 10.8.1.0 255.255.224.0</pre>	<p>Creates a standard access list, repeating the command as many times as necessary.</p> <ul style="list-style-type: none"> <li>• For <i>access-list-number</i>, enter the access list number specified in Step 2.</li> <li>• The <b>deny</b> keyword denies access if the conditions are matched.</li> <li>• The <b>permit</b> keyword permits access if the conditions are matched.</li> <li>• Create an access list that specifies from which routers and multilayer devices the mapping agent accepts candidate RP announcements (rp-list ACL).</li> <li>• Create an access list that specifies the range of multicast groups from which to accept or deny (group-list ACL).</li> <li>• For <i>source</i>, enter the multicast group address range for which the RP should be used.</li> <li>• (Optional) For <i>source-wildcard</i>, enter the wildcard bits in dotted decimal notation to be applied to the source. Place ones in the bit positions that you want to ignore.</li> </ul>

	Command or Action	Purpose
		The access list is always terminated by an implicit deny statement for everything.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Example: Filtering Incoming RP Announcement Messages](#), on page 573

## Configuring PIMv2 BSR

The process for configuring PIMv2 BSR may involve the following optional tasks:

- Defining the PIM domain border
- Defining the IP multicast boundary
- Configuring candidate BSRs
- Configuring candidate RPs

**Related Topics**

[Configuring Candidate BSRs \(CLI\)](#), on page 550

[PIMv2 Bootstrap Router](#), on page 526

### Defining the PIM Domain Border (CLI)

Perform the following steps to configure the PIM domain border. This procedure is optional.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>	Enables privileged EXEC mode.



	Command or Action	Purpose
	<b>Example:</b>  Device> <b>enable</b>	<ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b>  <b>Example:</b>  Device (config)# <b>interface gigabitethernet 1/0/1</b>	<p>Specifies the interface to be configured, and enters interface configuration mode.</p> <p>The specified interface must be one of the following:</p> <ul style="list-style-type: none"> <li>• A routed port—A physical port that has been configured as a Layer 3 port by entering the <b>no switchport</b> interface configuration command.</li> <li>• An SVI—A VLAN interface created by using the <b>interface vlan <i>vlan-id</i></b> global configuration command.</li> </ul> <p>These interfaces must have IP addresses assigned to them.</p>
<b>Step 4</b>	<b>ip pim bsr-border</b>  <b>Example:</b>  Device (config-if)# <b>ip pim bsr-border</b>	<p>Defines a PIM bootstrap message boundary for the PIM domain.</p> <p>Enter this command on each interface that connects to other bordering PIM domains. This command instructs the device to neither send nor receive PIMv2 BSR messages on this interface.</p> <p><b>Note</b> To remove the PIM border, use the <b>no ip pim bsr-border</b> interface configuration command.</p>
<b>Step 5</b>	<b>end</b>  <b>Example:</b>  Device (config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b>  <b>Example:</b>	Verifies your entries.

	Command or Action	Purpose
	Device# <code>show running-config</code>	
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[PIM Domain Border](#), on page 527

**Defining the IP Multicast Boundary (CLI)**

You define a multicast boundary to prevent Auto-RP messages from entering the PIM domain. You create an access list to deny packets destined for 224.0.1.39 and 224.0.1.40, which carry Auto-RP information.

This procedure is optional.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>access-list access-list-number deny source [source-wildcard]</b> <b>Example:</b> Device(config)# <code>access-list 12 deny 224.0.1.39</code> <code>access-list 12 deny 224.0.1.40</code>	Creates a standard access list, repeating the command as many times as necessary. <ul style="list-style-type: none"> <li>• For <i>access-list-number</i>, the range is 1 to 99.</li> <li>• The <b>deny</b> keyword denies access if the conditions are matched.</li> <li>• For <i>source</i>, enter multicast addresses 224.0.1.39 and 224.0.1.40, which carry Auto-RP information.</li> <li>• (Optional) For <i>source-wildcard</i>, enter the wildcard bits in dotted decimal notation to</li> </ul>

	Command or Action	Purpose
		<p>be applied to the source. Place ones in the bit positions that you want to ignore.</p> <p>The access list is always terminated by an implicit deny statement for everything.</p>
<b>Step 4</b>	<p><b>interface</b> <i>interface-id</i></p> <p><b>Example:</b></p> <pre>Device(config)# interface gigabitethernet 1/0/1</pre>	<p>Specifies the interface to be configured, and enters interface configuration mode.</p> <p>The specified interface must be one of the following:</p> <ul style="list-style-type: none"> <li>• A routed port—A physical port that has been configured as a Layer 3 port by entering the <b>no switchport</b> interface configuration command.</li> <li>• An SVI—A VLAN interface created by using the <b>interface vlan</b> <i>vlan-id</i> global configuration command.</li> </ul> <p>These interfaces must have IP addresses assigned to them.</p>
<b>Step 5</b>	<p><b>ip multicast boundary</b> <i>access-list-number</i></p> <p><b>Example:</b></p> <pre>Device(config-if)# ip multicast boundary 12</pre>	<p>Configures the boundary, specifying the access list you created in Step 2.</p>
<b>Step 6</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	<p>Returns to privileged EXEC mode.</p>
<b>Step 7</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	<p>Verifies your entries.</p>
<b>Step 8</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	<p>(Optional) Saves your entries in the configuration file.</p>

**Related Topics**

[Multicast Boundaries](#), on page 524

[Example: Defining the IP Multicast Boundary to Deny Auto-RP Information](#), on page 572

**Configuring Candidate BSRs (CLI)**

You can configure one or more candidate BSRs. The devices serving as candidate BSRs should have good connectivity to other devices and be in the backbone portion of the network.

This procedure is optional.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip pim bsr-candidate interface-id hash-mask-length [priority]</b> <b>Example:</b> Device(config)# <b>ip pim bsr-candidate gigabitethernet 1/0/3 28 100</b>	Configures your device to be a candidate BSR. <ul style="list-style-type: none"> <li>• For <i>interface-id</i>, enter the interface on this device from which the BSR address is derived to make it a candidate. This interface must be enabled with PIM. Valid interfaces include physical ports, port channels, and VLANs.</li> <li>• For <i>hash-mask-length</i>, specify the mask length (32 bits maximum) that is to be ANDed with the group address before the hash function is called. All groups with the same seed hash correspond to the same RP. For example, if this value is 24, only the first 24 bits of the group addresses matter.</li> <li>• (Optional) For <i>priority</i>, enter a number from 0 to 255. The BSR with the larger priority is preferred. If the priority values are the same, the device with the highest IP address is selected as the BSR. The default is 0.</li> </ul>

	Command or Action	Purpose
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

#### Related Topics

- [PIMv2 Bootstrap Router](#), on page 526
- [Configuring PIMv2 BSR](#), on page 546
- [Example: Configuring Candidate BSRs](#), on page 573
- [Restrictions for Configuring Auto-RP and BSR](#), on page 517

## Configuring the Candidate RPs (CLI)

You can configure one or more candidate RPs. Similar to BSRs, the RPs should also have good connectivity to other devices and be in the backbone portion of the network. An RP can serve the entire IP multicast address space or a portion of it. Candidate RPs send candidate RP advertisements to the BSR.

This procedure is optional.

#### Before you begin

When deciding which devices should be RPs, consider these options:

- In a network of Cisco routers and multilayer devices where only Auto-RP is used, any device can be configured as an RP.
- In a network that includes only Cisco PIMv2 routers and multilayer devices and with routers from other vendors, any device can be used as an RP.
- In a network of Cisco PIMv1 routers, Cisco PIMv2 routers, and routers from other vendors, configure only Cisco PIMv2 routers and multilayer devices as RPs.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip pim rp-candidate</b> <i>interface-id</i> [ <b>group-list</b> <i>access-list-number</i> ] <b>Example:</b> Device(config)# <b>ip pim rp-candidate</b> <b>gigabitethernet 1/0/5 group-list 10</b>	Configures your device to be a candidate RP. <ul style="list-style-type: none"> <li>• For <i>interface-id</i>, specify the interface whose associated IP address is advertised as a candidate RP address. Valid interfaces include physical ports, port channels, and VLANs.</li> <li>• (Optional) For <b>group-list</b> <i>access-list-number</i>, enter an IP standard access list number from 1 to 99. If no group-list is specified, the device is a candidate RP for all groups.</li> </ul>
<b>Step 4</b>	<b>access-list</b> <i>access-list-number</i> { <b>deny</b>   <b>permit</b> } <i>source</i> [ <i>source-wildcard</i> ] <b>Example:</b> Device(config)# <b>access-list 10 permit</b> <b>239.0.0.0 0.255.255.255</b>	Creates a standard access list, repeating the command as many times as necessary. <ul style="list-style-type: none"> <li>• For <i>access-list-number</i>, enter the access list number specified in Step 2.</li> <li>• The <b>deny</b> keyword denies access if the conditions are matched. The <b>permit</b> keyword permits access if the conditions are matched.</li> <li>• For <i>source</i>, enter the number of the network or host from which the packet is being sent.</li> <li>• (Optional) For <i>source-wildcard</i>, enter the wildcard bits in dotted decimal notation to be applied to the source. Place ones in the bit positions that you want to ignore.</li> </ul> <p>The access list is always terminated by an implicit deny statement for everything.</p>

	Command or Action	Purpose
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Rendezvous Points](#), on page 523

[Configuring a Rendezvous Point](#), on page 536

[Example: Configuring Candidate RPs](#), on page 574

## Configuring Sparse Mode with Auto-RP(CLI)

**Before you begin**

- All access lists that are needed when Auto-RP is configured should be configured prior to beginning the configuration task.

**Note**

- If a group has no known RP and the interface is configured to be sparse-dense mode, the interface is treated as if it were in dense mode, and data is flooded over the interface. To avoid this data flooding, configure the Auto-RP listener and then configure the interface as sparse mode.
- When configuring Auto-RP, you must either configure the Auto-RP listener feature (Step 5) and specify sparse mode (Step 7).
- When you configure sparse-dense mode, dense mode failover may result in a network dense-mode flood. To avoid this condition, use PIM sparse mode with the Auto-RP listener feature.

Follow this procedure to configure auto-rendezvous point (Auto-RP). Auto-RP can also be optionally used with anycast RP.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip multicast-routing [distributed]</b> <b>Example:</b>  Device(config)# ip multicast-routing	Enables IP multicast routing.  • Use the <b>distributed</b> keyword to enabled Multicast Distributed Switching.
<b>Step 4</b>	Either perform Steps 5 through 7 or perform Steps 6 and 8.	--
<b>Step 5</b>	<b>interface type number</b> <b>Example:</b>  Device(config)# interface Gigabitethernet 1/0/0	Selects an interface that is connected to hosts on which PIM can be enabled.
<b>Step 6</b>	<b>ip pim sparse-mode</b> <b>Example:</b>  Device(config-if)# ip pim sparse-mode	Enables PIM sparse mode on an interface. When configuring Auto-RP in sparse mode, you must also configure the Auto-RP listener in the next step.  • Skip this step if you are configuring sparse-dense mode in Step 8.
<b>Step 7</b>	<b>exit</b> <b>Example:</b>  Device(config-if)# exit	Exits interface configuration mode and returns to global configuration mode.
<b>Step 8</b>	Repeat Steps 1 through 9 on all PIM interfaces.	--
<b>Step 9</b>	<b>ip pim send-rp-announce {interface-type interface-number   ip-address} scope ttl-value [group-list access-list] [interval seconds] [bidir]</b> <b>Example:</b>  Device(config)# ip pim send-rp-announce loopback0 scope 31 group-list 5	Sends RP announcements out all PIM-enabled interfaces.  • Perform this step on the RP device only.  • Use the <i>interface-type</i> and <i>interface-number</i> arguments to define which IP address is to be used as the RP address.



	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>Use the <i>ip-address</i> argument to specify a directly connected IP address as the RP address.</li> </ul> <p><b>Note</b> If the <i>ip-address</i> argument is configured for this command, the RP-announce message will be sourced by the interface to which this IP address is connected (that is, the source address in the IP header of the RP-announce message is the IP address of that interface).</p> <ul style="list-style-type: none"> <li>This example shows that the interface is enabled with a maximum of 31 hops. The IP address by which the device wants to be identified as RP is the IP address associated with loopback interface 0. Access list 5 describes the groups for which this device serves as RP.</li> </ul>
<b>Step 10</b>	<p><b>ip pim send-rp-discovery</b> [<i>interface-type interface-number</i>] <b>scope</b> <i>tvl-value</i> [<b>interval</b> <i>seconds</i>]</p> <p><b>Example:</b></p> <pre>Device(config)# ip pim send-rp-discovery loopback 1 scope 31</pre>	<p>Configures the device to be an RP mapping agent.</p> <ul style="list-style-type: none"> <li>Perform this step on RP mapping agent devices or on combined RP/RP mapping agent devices.</li> </ul> <p><b>Note</b> Auto-RP allows the RP function to run separately on one device and the RP mapping agent to run on one or multiple devices. It is possible to deploy the RP and the RP mapping agent on a combined RP/RP mapping agent device.</p> <ul style="list-style-type: none"> <li>Use the optional <i>interface-type</i> and <i>interface-number</i> arguments to define which IP address is to be used as the source address of the RP mapping agent.</li> <li>Use the <b>scope</b> keyword and <i>tvl-value</i> argument to specify the Time-to-Live (TTL) value in the IP header of Auto-RP discovery messages.</li> <li>Use the optional <b>interval</b> keyword and <i>seconds</i> argument to specify the interval at which Auto-RP discovery messages are sent.</li> </ul>

	Command or Action	Purpose
		<p><b>Note</b> Lowering the interval at which Auto-RP discovery messages are sent from the default value of 60 seconds results in more frequent floodings of the group-to-RP mappings. In some network environments, the disadvantages of lowering the interval (more control packet overhead) may outweigh the advantages (more frequent group-to-RP mapping updates).</p> <ul style="list-style-type: none"> <li>• The example shows limiting the Auto-RP discovery messages to 31 hops on loopback interface 1.</li> </ul>
<b>Step 11</b>	<p><b>ip pim rp-announce-filter rp-list <i>access-list</i> group-list <i>access-list</i></b></p> <p><b>Example:</b></p> <pre>Device(config)# ip pim rp-announce-filter rp-list 1 group-list 2</pre>	<p>Filters incoming RP announcement messages sent from candidate RPs (C-RPs) to the RP mapping agent.</p> <ul style="list-style-type: none"> <li>• Perform this step on the RP mapping agent only.</li> </ul>
<b>Step 12</b>	<p><b>interface <i>type number</i></b></p> <p><b>Example:</b></p> <pre>Device(config)# interface gigabitethernet 1/0/0</pre>	<p>Selects an interface that is connected to hosts on which PIM can be enabled.</p>
<b>Step 13</b>	<p><b>ip multicast boundary <i>access-list</i> [filter-autorp]</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# ip multicast boundary 10 filter-autorp</pre>	<p>Configures an administratively scoped boundary.</p> <ul style="list-style-type: none"> <li>• Perform this step on the interfaces that are boundaries to other devices.</li> <li>• The access list is not shown in this task.</li> <li>• An access list entry that uses the <b>deny</b> keyword creates a multicast boundary for packets that match that entry.</li> </ul>
<b>Step 14</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# end</pre>	<p>Returns to global configuration mode.</p>
<b>Step 15</b>	<p><b>show ip pim autorp</b></p> <p><b>Example:</b></p>	<p>(Optional) Displays the Auto-RP information.</p>

	Command or Action	Purpose
	Device# show ip pim autorp	
<b>Step 16</b>	<b>show ip pim rp [mapping] [rp-address]</b> <b>Example:</b> Device# show ip pim rp mapping	(Optional) Displays RPs known in the network and shows how the device learned about each RP.
<b>Step 17</b>	<b>show ip igmp groups [group-name   group-address   interface-type interface-number] [detail]</b> <b>Example:</b> Device# show ip igmp groups	(Optional) Displays the multicast groups having receivers that are directly connected to the device and that were learned through Internet Group Management Protocol (IGMP). <ul style="list-style-type: none"> <li>• A receiver must be active on the network at the time that this command is issued in order for receiver information to be present on the resulting display.</li> </ul>
<b>Step 18</b>	<b>show ip mroute [group-address   group-name] [source-address   source-name] [interface-type interface-number] [summary] [count] [active kbps]</b> <b>Example:</b> Device# show ip mroute cbone-audio	(Optional) Displays the contents of the IP multicast routing (mroute) table.

## Delaying the Use of PIM Shortest-Path Tree (CLI)

Perform these steps to configure a traffic rate threshold that must be reached before multicast routing is switched from the source tree to the shortest-path tree.

This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<p><b>access-list</b> <i>access-list-number</i> {deny   permit} <i>source</i> [<i>source-wildcard</i>]</p> <p><b>Example:</b></p> <pre>Device(config)# access-list 16 permit 225.0.0.0 0.255.255.255</pre>	<p>Creates a standard access list.</p> <ul style="list-style-type: none"> <li>For <i>access-list-number</i>, the range is 1 to 99.</li> <li>The <b>deny</b> keyword denies access if the conditions are matched.</li> <li>The <b>permit</b> keyword permits access if the conditions are matched.</li> <li>For <i>source</i>, specify the multicast group to which the threshold will apply.</li> <li>(Optional) For <i>source-wildcard</i>, enter the wildcard bits in dotted decimal notation to be applied to the source. Place ones in the bit positions that you want to ignore.</li> </ul> <p>The access list is always terminated by an implicit deny statement for everything.</p>
<b>Step 4</b>	<p><b>ip pim spt-threshold</b> {<i>kbps</i>   infinity} [<b>group-list</b> <i>access-list-number</i>]</p> <p><b>Example:</b></p> <pre>Device(config)# ip pim spt-threshold infinity group-list 16</pre>	<p>Specifies the threshold that must be reached before moving to shortest-path tree (spt).</p> <ul style="list-style-type: none"> <li>For <i>kbps</i>, specify the traffic rate in kilobits per second. The default is 0 kbps.</li> </ul> <p><b>Note</b> Because of device hardware limitations, 0 kbps is the only valid entry even though the range is 0 to 4294967.</p> <ul style="list-style-type: none"> <li>Specify <b>infinity</b> if you want all sources for the specified group to use the shared tree, never switching to the source tree.</li> <li>(Optional) For <b>group-list</b> <i>access-list-number</i>, specify the access list created in Step 2. If the value is 0 or if the group list is not used, the threshold applies to all groups.</li> </ul>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p>	Verifies your entries.

	Command or Action	Purpose
	Device# <code>show running-config</code>	
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[PIM Shared Tree and Source Tree](#), on page 530

## Modifying the PIM Router-Query Message Interval (CLI)

PIM routers and multilayer devices send PIM router-query messages to find which device will be the designated router (DR) for each LAN segment (subnet). The DR is responsible for sending IGMP host-query messages to all hosts on the directly connected LAN.

With PIM DM operation, the DR has meaning only if IGMPv1 is in use. IGMPv1 does not have an IGMP querier election process, so the elected DR functions as the IGMP querier. With PIM-SM operation, the DR is the device that is directly connected to the multicast source. It sends PIM register messages to notify the RP that multicast traffic from a source needs to be forwarded down the shared tree. In this case, the DR is the device with the highest IP address.

This procedure is optional.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <code>interface gigabitethernet 1/0/1</code>	Specifies the interface to be configured, and enters interface configuration mode. The specified interface must be one of the following: <ul style="list-style-type: none"> <li>• A routed port—A physical port that has been configured as a Layer 3 port by</li> </ul>

	Command or Action	Purpose
		<p>entering the <b>no switchport</b> interface configuration command.</p> <ul style="list-style-type: none"> <li>An SVI—A VLAN interface created by using the <b>interface vlan <i>vlan-id</i></b> global configuration command.</li> </ul> <p>These interfaces must have IP addresses assigned to them.</p>
<b>Step 4</b>	<p><b>ip pim query-interval <i>seconds</i></b></p> <p><b>Example:</b></p> <pre>Device(config-if)# ip pim query-interval 45</pre>	<p>Configures the frequency at which the device sends PIM router-query messages.</p> <p>The default is 30 seconds. The range is 1 to 65535.</p>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	<p>Returns to privileged EXEC mode.</p>
<b>Step 6</b>	<p><b>show ip igmp interface [<i>interface-id</i>]</b></p> <p><b>Example:</b></p> <pre>Device# show ip igmp interface</pre>	<p>Verifies your entries.</p>
<b>Step 7</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	<p>(Optional) Saves your entries in the configuration file.</p>

## Verifying PIM Operations

### Verifying IP Multicast Operation in a PIM-SM or a PIM-SSM Network

When you verify the operation of IP multicast in a PIM-SM network environment or in a PIM-SSM network environment, a useful approach is to begin the verification process on the last hop router, and then continue the verification process on the routers along the SPT until the first hop router has been reached. The goal of the verification is to ensure that IP multicast traffic is being routed properly through an IP multicast network.

Perform the following optional tasks to verify IP multicast operation in a PIM-SM or a PIM-SSM network. The steps in these tasks help to locate a faulty hop when sources and receivers are not operating as expected.



**Note** If packets are not reaching their expected destinations, you might want consider disabling IP multicast fast switching, which would place the router in process switching mode. If packets begin reaching their proper destinations after IP multicast fast switching has been disabled, then the issue most likely was related to IP multicast fast switching.

## Verifying IP Multicast on the First Hop Router

Enter these commands on the first hop router to verify IP multicast operations on the first hop router:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>show ip mroute [group-address]</b> <b>Example:</b> Device# <b>show ip mroute 239.1.2.3</b> (*, 239.1.2.3), 00:18:10/stopped, RP 172.16.0.1, flags: SPF Incoming interface: Serial1/0, RPF nbr 172.31.200.2 Outgoing interface list: Null  (10.0.0.1, 239.1.2.3), 00:18:10/00:03:22, flags: FT Incoming interface: GigabitEthernet0/0/0, RPF nbr 0.0.0.0 Outgoing interface list: Serial1/0, Forward/Sparse, 00:18:10/00:03:19	Confirms that the F flag has been set for mroutes on the first hop router.
<b>Step 3</b>	<b>show ip mroute active [kb/s]</b> <b>Example:</b> Device# <b>show ip mroute active</b> Active IP Multicast Sources - sending >= 4 kbps	Displays information about active multicast sources sending to groups. The output of this command provides information about the multicast packet rate for active sources.

	Command or Action	Purpose
	<pre>Group: 239.1.2.3, (?) Source: 10.0.0.1 (?) Rate: 20 pps/4 kbps(1sec), 4 kbps(last 30 secs), 4 kbps(life avg)</pre>	<p><b>Note</b> By default, the output of the <b>show ip mroute</b> command with the <b>active</b> keyword displays information about active sources sending traffic to groups at a rate greater than or equal to 4 kb/s. To display information about active sources sending low-rate traffic to groups (that is, traffic less than 4 kb/s), specify a value of 1 for the <i>kb/s</i> argument. Specifying a value of 1 for this argument displays information about active sources sending traffic to groups at a rate equal to or greater than 1 kb/s, which effectively displays information about all possible active source traffic.</p>

## Verifying IP Multicast on Routers Along the SPT

Enter these commands on routers along the SPT to verify IP multicast operations on routers along the SPT in a PIM-SM or PIM-SSM network:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<p><b>show ip mroute</b> [<i>group-address</i>]</p> <p><b>Example:</b></p> <pre>Device# show ip mroute 239.1.2.3 (*, 239.1.2.3), 00:17:56/00:03:02, RP 172.16.0.1, flags: S Incoming interface: Null, RPF nbr 0.0.0.0 Outgoing interface list: GigabitEthernet0/0/0, Forward/Sparse, 00:17:56/00:03:02  (10.0.0.1, 239.1.2.3), 00:15:34/00:03:28, flags: T Incoming interface: Serial1/0, RPF nbr 172.31.200.1 Outgoing interface list: GigabitEthernet0/0/0, Forward/Sparse, 00:15:34/00:03:02</pre>	<p>Confirms the RPF neighbor towards the source for a particular group or groups.</p>



	Command or Action	Purpose
<b>Step 3</b>	<p><b>show ip mroute active</b></p> <p><b>Example:</b></p> <pre>Device# show ip mroute active Active IP Multicast Sources - sending &gt;= 4 kbps  Group: 239.1.2.3, (?) Source: 10.0.0.1 (?) Rate: 20 pps/4 kbps(1sec), 4 kbps(last 30 secs), 4 kbps(life avg)</pre>	<p>Displays information about active multicast sources sending to groups. The output of this command provides information about the multicast packet rate for active sources.</p> <p><b>Note</b> By default, the output of the <b>show ip mroute</b> command with the <b>active</b> keyword displays information about active sources sending traffic to groups at a rate greater than or equal to 4 kb/s. To display information about active sources sending low-rate traffic to groups (that is, traffic less than 4 kb/s), specify a value of 1 for the <i>kb/s</i> argument. Specifying a value of 1 for this argument displays information about active sources sending traffic to groups at a rate equal to or greater than 1 kb/s, which effectively displays information about all possible active source traffic.</p>

## Verifying IP Multicast Operation on the Last Hop Router

Enter these commands on the last hop router to verify IP multicast operations on the last hop router:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<p><b>show ip igmp groups</b></p> <p><b>Example:</b></p> <pre>Device# show ip igmp groups IGMP Connected Group Membership Group Address  Interface Uptime        Expires      Last Reporter 239.1.2.3      GigabitEthernet1/0/0 00:05:14      00:02:14    10.1.0.6 224.0.1.39     GigabitEthernet0/0/0 00:09:11      00:02:08    172.31.100.1</pre>	<p>Verifies IGMP memberships on the last hop router. This information will confirm the multicast groups with receivers that are directly connected to the last hop router and that are learned through IGMP.</p>
<b>Step 3</b>	<p><b>show ip pim rp mapping</b></p> <p><b>Example:</b></p>	<p>Confirms that the group-to-RP mappings are being populated correctly on the last hop router.</p>

	Command or Action	Purpose
	<pre>Device# show ip pim rp mapping PIM Group-to-RP Mappings  Group(s) 224.0.0.0/4   RP 172.16.0.1 (?), v2v1     Info source: 172.16.0.1 (?), elected     via Auto-RP       Uptime: 00:09:11, expires: 00:02:47</pre>	<p><b>Note</b> Ignore this step if you are verifying a last hop router in a PIM-SSM network. The <b>show ip pim rp mapping</b> command does not work with routers in a PIM-SSM network because PIM-SSM does not use RPs. In addition, if configured correctly, PIM-SSM groups do not appear in the output of the <b>show ip pim rp mapping</b> command.</p>
<b>Step 4</b>	<p><b>show ip mroute</b></p> <p><b>Example:</b></p> <pre>Device# show ip mroute (*, 239.1.2.3), 00:05:14/00:03:04, RP 172.16.0.1, flags: SJC   Incoming interface: GigabitEthernet0/0/0, RPF nbr 172.31.100.1   Outgoing interface list: GigabitEthernet1/0, Forward/Sparse, 00:05:10/00:03:04  (10.0.0.1, 239.1.2.3), 00:02:49/00:03:29, flags: T   Incoming interface: GigabitEthernet0/0/0, RPF nbr 172.31.100.1   Outgoing interface list: GigabitEthernet1/0, Forward/Sparse, 00:02:49/00:03:04  (*, 224.0.1.39), 00:10:05/00:00:00, RP 0.0.0.0, flags: DC   Incoming interface: Null, RPF nbr 0.0.0.0   Outgoing interface list: GigabitEthernet1/0, Forward/Sparse, 00:05:15/00:00:00 GigabitEthernet0/0, Forward/Sparse, 00:10:05/00:00:00  (172.16.0.1, 224.0.1.39), 00:02:00/00:01:33, flags: PTX   Incoming interface: GigabitEthernet0/0/0, RPF nbr 172.31.100.1</pre>	<p>Verifies that the mroute table is being populated properly on the last hop router.</p>
<b>Step 5</b>	<p><b>show ip interface [type number]</b></p> <p><b>Example:</b></p> <pre>Device# show ip interface GigabitEthernet 0/0/0</pre>	<p>Verifies that multicast fast switching is enabled for optimal performance on the outgoing interface on the last hop router.</p>

	Command or Action	Purpose
	<pre>GigabitEthernet0/0 is up, line protocol is up Internet address is 172.31.100.2/24 Broadcast address is 255.255.255.255 Address determined by setup command MTU is 1500 bytes Helper address is not set Directed broadcast forwarding is disabled Multicast reserved groups joined: 224.0.0.1 224.0.0.22 224.0.0.13 224.0.0.5 224.0.0.6 Outgoing access list is not set Inbound access list is not set Proxy ARP is enabled Local Proxy ARP is disabled Security level is default Split horizon is enabled ICMP redirects are always sent ICMP unreachable are always sent ICMP mask replies are never sent IP fast switching is enabled IP fast switching on the same interface is disabled IP Flow switching is disabled IP CEF switching is disabled IP Fast switching turbo vector IP multicast fast switching is enabled  IP multicast distributed fast switching is disabled IP route-cache flags are Fast Router Discovery is disabled IP output packet accounting is disabled  IP access violation accounting is disabled TCP/IP header compression is disabled RTP/IP header compression is disabled Policy routing is disabled Network address translation is disabled  WCCP Redirect outbound is disabled WCCP Redirect inbound is disabled WCCP Redirect exclude is disabled BGP Policy Mapping is disabled</pre>	<p><b>Note</b> Using the <b>no ip mroute-cache</b> interface command disables IP multicast fast-switching. When IP multicast fast switching is disabled, packets are forwarded through the process-switched path.</p>
<b>Step 6</b>	<p><b>show ip mfib</b></p> <p><b>Example:</b></p> <pre>Device# show ip mfib</pre>	Displays the forwarding entries and interfaces in the IP Multicast Forwarding Information Base (MFIB).
<b>Step 7</b>	<p><b>show ip pim interface count</b></p> <p><b>Example:</b></p> <pre>Device# show ip pim interface count  State: * - Fast Switched, D - Distributed Fast Switched H - Hardware Switching Enabled Address Interface</pre>	Confirms that multicast traffic is being forwarded on the last hop router.

	Command or Action	Purpose
	<pre> FS Mpackets In/Out 172.31.100.2 GigabitEthernet0/0/0 * 4122/0 10.1.0.1 GigabitEthernet1/0/0 * 0/3193 </pre>	
<b>Step 8</b>	<p><b>show ip mroute count</b></p> <p><b>Example:</b></p> <pre> Device# show ip mroute count IP Multicast Statistics 6 routes using 4008 bytes of memory 3 groups, 1.00 average sources per group Forwarding Counts: Pkt Count/Pkts per second/Avg Pkt Size/Kilobits per second Other counts: Total/RPF failed/Other drops(OIF-null, rate-limit etc)  Group: 239.1.2.3, Source count: 1, Packets forwarded: 3165, Packets received: 3165 RP-tree: Forwarding: 0/0/0/0, Other: 0/0/0 Source: 10.0.0.1/32, Forwarding: 3165/20/28/4, Other: 0/0/0  Group: 224.0.1.39, Source count: 1, Packets forwarded: 21, Packets received: 120 Source: 172.16.0.1/32, Forwarding: 21/1/48/0, Other: 120/0/99  Group: 224.0.1.40, Source count: 1, Packets forwarded: 10, Packets received: 10 Source: 172.16.0.1/32, Forwarding: 10/1/48/0, Other: 10/0/0 </pre>	Confirms that multicast traffic is being forwarded on the last hop router.
<b>Step 9</b>	<p><b>show ip mroute active [kb/s]</b></p> <p><b>Example:</b></p> <pre> Device# show ip mroute active Active IP Multicast Sources - sending &gt;= 4 kbps </pre>	Displays information about active multicast sources sending traffic to groups on the last hop router. The output of this command provides information about the multicast packet rate for active sources.

	Command or Action	Purpose
	<pre>Group: 239.1.2.3, (?) Source: 10.0.0.1 (?) Rate: 20 pps/4 kbps(1sec), 4 kbps(last 50 secs), 4 kbps(life avg)</pre>	<p><b>Note</b> By default, the output of the <b>show ip mroute</b> command with the <b>active</b> keyword displays information about active sources sending traffic to groups at a rate greater than or equal to 4 kb/s. To display information about active sources sending low-rate traffic to groups (that is, traffic less than 4 kb/s), specify a value of 1 for the <i>kb/s</i> argument. Specifying a value of 1 for this argument displays information about active sources sending traffic to groups at a rate equal to or greater than 1 kb/s, which effectively displays information about all possible active source traffic.</p>

## Using PIM-Enabled Routers to Test IP Multicast Reachability

If all the PIM-enabled routers and access servers that you administer are members of a multicast group, pinging that group causes all routers to respond, which can be a useful administrative and debugging tool.

To use PIM-enabled routers to test IP multicast reachability, perform the following tasks:

### Configuring Routers to Respond to Multicast Pings

Follow these steps to configure a router to respond to multicast pings. Perform the task on all the interfaces of a router and on all the routers participating in the multicast network:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<pre>enable</pre> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<pre>configure terminal</pre> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<pre>interface type number</pre> <p><b>Example:</b></p>	<p>Enters interface configuration mode.</p> <p>For the <i>type</i> and <i>number</i> arguments, specify an interface that is directly connected to hosts or is facing hosts.</p>

	Command or Action	Purpose
	Device(config)# <b>interface</b> gigabitethernet 1/0/0	
<b>Step 4</b>	<b>ip igmp join-group</b> <i>group-address</i>  <b>Example:</b>  Device(config-if)# <b>ip igmp join-group</b> 225.2.2.2	(Optional) Configures an interface on the router to join the specified group.  For the purpose of this task, configure the same group address for the <i>group-address</i> argument on all interfaces on the router participating in the multicast network.  <b>Note</b> With this method, the router accepts the multicast packets in addition to forwarding them. Accepting the multicast packets prevents the router from fast switching.
<b>Step 5</b>	Repeat Step 3 and Step 4 for each interface on the router participating in the multicast network.	--
<b>Step 6</b>	<b>end</b>  <b>Example:</b>  Device(config-if)# <b>end</b>	Ends the current configuration session and returns to privileged EXEC mode.

## Pinging Routers Configured to Respond to Multicast Pings

Follow these steps on a router to initiate a ping test to the routers configured to respond to multicast pings. This task is used to test IP multicast reachability in a network.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>ping</b> <i>group-address</i>  <b>Example:</b>  Device# <b>ping</b> 225.2.2.2	Pings an IP multicast group address.  A successful response indicates that the group address is functioning.

# Monitoring and Troubleshooting PIM

## Monitoring PIM Information

Use the privileged EXEC commands in the following table to monitor your PIM configurations.

**Table 43: PIM Monitoring Commands**

Command	Purpose
<b>show ip pim all-vrfs tunnel</b> [ <b>tunnel</b> <i>tunnel_number</i>   <b>verbose</b> ]	Displays all VRFs.
<b>show ip pim autorp</b>	Displays global auto-RP information.
<b>show ip pim boundary</b>	Displays information about mroutes filtered by administratively scoped IPv4 multicast boundaries configured on an interface.
<b>show ip pim interface</b>	Displays information about interfaces configured for Protocol Independent Multicast (PIM).
<b>show ip pim neighbor</b>	Displays the PIM neighbor information.
<b>show ip pim rp</b> [ <i>group-name</i>   <i>group-address</i> ]	Displays RP routers associated with a sparse-mode multicast group. This command is available in all software images.
<b>show ip pim tunnel</b> [ <b>tunnel</b>   <b>verbose</b> ]	Displays information about Protocol Independent Multicast (PIM) tunnel interfaces
<b>show ip pim vrf</b> { <b>word</b> { <b>all-vrfs</b>   <b>autorp</b>   <b>boundary</b>   <b>bsr-router</b>   <b>interface</b>   <b>mdt</b>   <b>neighbor</b>   <b>rp</b>   <b>rp-hash</b>   <b>tunnel</b> } }	Displays the VPN routing/forwarding instance.
<b>show ip igmp groups detail</b>	Displays the interested clients that have joined the specific multicast source group.

## Monitoring the RP Mapping and BSR Information

Use the privileged EXEC mode in the following table to verify the consistency of group-to-RP mappings:

**Table 44: RP Mapping Monitoring Commands**

Command	Purpose
<b>show ip pim rp</b> [ <i>hostname</i> or <i>IP address</i>   <b>mapping</b> [ <i>hostname</i> or <i>IP address</i>   <b>elected</b>   <b>in-use</b> ]   <b>metric</b> [ <i>hostname</i> or <i>IP address</i> ] ]	<p>Displays all available RP mappings and metrics. This tells you how the device learns of the RP (through the BSR or the Auto-RP mechanism).</p> <ul style="list-style-type: none"> <li>• (Optional) For the <i>hostname</i>, specify the IP name of the group about which to display RPs.</li> <li>• (Optional) For the <i>IP address</i>, specify the IP address of the group about which to display RPs.</li> <li>• (Optional) Use the <b>mapping</b> keyword to display all group-to-RP mappings of which the Cisco device is aware (either configured or learned from Auto-RP).</li> <li>• (Optional) Use the <b>metric</b> keyword to display the RP RPF metric.</li> </ul>
<b>show ip pim rp-hash</b> <i>group</i>	<p>Displays the RP that was selected for the specified group. That is, on a PIMv2 router or multilayer device, confirms that the same RP is the one that a PIMv1 system chooses. For <i>group</i>, enter the group address for which to display RP information.</p>

Use the privileged EXEC commands in the following table to monitor BSR information:

**Table 45: BSR Monitoring Commands**

Command	Purpose
<b>show ip pim bsr</b>	Displays information about the elected BSR.
<b>show ip pim bsr-router</b>	Displays information about the BSRv2.

## Troubleshooting PIMv1 and PIMv2 Interoperability Problems

When debugging interoperability problems between PIMv1 and PIMv2, check these in the order shown:

1. Verify RP mapping with the **show ip pim rp-hash** privileged EXEC command, making sure that all systems agree on the same RP for the same group.
2. Verify interoperability between different versions of DRs and RPs. Make sure that the RPs are interacting with the DRs properly (by responding with register-stops and forwarding decapsulated data packets from registers).

### Related Topics

[PIM Versions](#), on page 521



# Configuration Examples for PIM

## Example: Enabling PIM Stub Routing

In this example, IP multicast routing is enabled, Switch A PIM uplink port 25 is configured as a routed uplink port with **spare-dense-mode** enabled. PIM stub routing is enabled on the VLAN 100 interfaces and on Gigabit Ethernet port 20.

```
Device(config)# ip multicast-routing distributed
Device(config)# interface GigabitEthernet3/0/25
Device(config-if)# no switchport
Device(config-if)# ip address 3.1.1.2 255.255.255.0
Device(config-if)# ip pim sparse-dense-mode
Device(config-if)# exit
Device(config)# interface vlan100
Device(config-if)# ip pim passive
Device(config-if)# exit
Device(config)# interface GigabitEthernet3/0/20
Device(config-if)# ip pim passive
Device(config-if)# exit
Device(config)# interface vlan100
Device(config-if)# ip address 100.1.1.1 255.255.255.0
Device(config-if)# ip pim passive
Device(config-if)# exit
Device(config)# interface GigabitEthernet3/0/20
Device(config-if)# no switchport
Device(config-if)# ip address 10.1.1.1 255.255.255.0
Device(config-if)# ip pim passive
Device(config-if)# end
```

### Related Topics

[Enabling PIM Stub Routing \(CLI\)](#), on page 534

[PIM Stub Routing](#), on page 521

## Example: Verifying PIM Stub Routing

To verify that PIM stub is enabled for each interface, use the **show ip pim interface** privileged EXEC command:

```
Device# show ip pim interface
Address Interface Ver/ Nbr Query DR DR
Mode Count Intvl Prior
3.1.1.2 GigabitEthernet3/0/25 v2/SD 1 30 1 3.1.1.2
100.1.1.1 Vlan100 v2/P 0 30 1 100.1.1.1
10.1.1.1 GigabitEthernet3/0/20 v2/P 0 30 1 10.1.1.1
```

### Related Topics

[Enabling PIM Stub Routing \(CLI\)](#), on page 534

[PIM Stub Routing](#), on page 521

## Example: Manually Assigning an RP to Multicast Groups

This example shows how to configure the address of the RP to 147.106.6.22 for multicast group 225.2.2.2 only:

```
Device(config)# access-list 1 permit 225.2.2.2 0.0.0.0
Device(config)# ip pim rp-address 147.106.6.22 1
```

### Related Topics

[Manually Assigning an RP to Multicast Groups \(CLI\)](#), on page 536

## Example: Configuring Auto-RP

This example shows how to send RP announcements out all PIM-enabled interfaces for a maximum of 31 hops. The IP address of port 1 is the RP. Access list 5 describes the group for which this device serves as RP:

```
Device(config)# ip pim send-rp-announce gigabitethernet1/0/1 scope 31 group-list 5
Device(config)# access-list 5 permit 224.0.0.0 15.255.255.255
```

### Related Topics

[Setting Up Auto-RP in a New Internetwork \(CLI\)](#), on page 538

[Auto-RP](#), on page 523

## Example: Sparse Mode with Auto-RP

The following example configures sparse mode with Auto-RP:

```
ip multicast-routing
ip pim autorp listener
ip pim send-rp-announce Loopback0 scope 16 group-list 1
ip pim send-rp-discovery Loopback1 scope 16
no ip pim dm-fallback
access-list 1 permit 239.254.2.0 0.0.0.255
access-list 1 permit 239.254.3.0 0.0.0.255
.
.
.
access-list 10 permit 224.0.1.39
access-list 10 permit 224.0.1.40
access-list 10 permit 239.254.2.0 0.0.0.255
access-list 10 permit 239.254.3.0 0.0.0.255
```

### Related Topics

[Setting Up Auto-RP in a New Internetwork \(CLI\)](#), on page 538

[Auto-RP](#), on page 523

## Example: Defining the IP Multicast Boundary to Deny Auto-RP Information

This example shows a portion of an IP multicast boundary configuration that denies Auto-RP information:

```
Device(config)# access-list 1 deny 224.0.1.39
```

```
Device(config)# access-list 1 deny 224.0.1.40
Device(config)# access-list 1 permit all
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip multicast boundary 1
```

### Related Topics

[Defining the IP Multicast Boundary \(CLI\)](#), on page 548

[Multicast Boundaries](#), on page 524

## Example: Filtering Incoming RP Announcement Messages

This example shows a sample configuration on an Auto-RP mapping agent that is used to prevent candidate RP announcements from being accepted from unauthorized candidate RPs:

```
Device(config)# ip pim rp-announce-filter rp-list 10 group-list 20
Device(config)# access-list 10 permit host 172.16.5.1
Device(config)# access-list 10 permit host 172.16.2.1
Device(config)# access-list 20 deny 239.0.0.0 0.0.255.255
Device(config)# access-list 20 permit 224.0.0.0 15.255.255.255
```

The mapping agent accepts candidate RP announcements from only two devices, 172.16.5.1 and 172.16.2.1. The mapping agent accepts candidate RP announcements from these two devices only for multicast groups that fall in the group range of 224.0.0.0 to 239.255.255.255. The mapping agent does not accept candidate RP announcements from any other devices in the network. Furthermore, the mapping agent does not accept candidate RP announcements from 172.16.5.1 or 172.16.2.1 if the announcements are for any groups in the 239.0.0.0 through 239.255.255.255 range. This range is the administratively scoped address range.

### Related Topics

[Filtering Incoming RP Announcement Messages \(CLI\)](#), on page 544

## Example: Preventing Join Messages to False RPs

If all interfaces are in sparse mode, use a default-configured RP to support the two well-known groups 224.0.1.39 and 224.0.1.40. Auto-RP uses these two well-known groups to collect and distribute RP-mapping information. When this is the case and the **ip pim accept-rp auto-rp** command is configured, another **ip pim accept-rp** command accepting the RP must be configured as follows:

```
Device(config)# ip pim accept-rp 172.10.20.1 1
Device(config)# access-list 1 permit 224.0.1.39
Device(config)# access-list 1 permit 224.0.1.40
```

### Related Topics

[Preventing Join Messages to False RPs \(CLI\)](#), on page 544

## Example: Configuring Candidate BSRs

This example shows how to configure a candidate BSR, which uses the IP address 172.21.24.18 on a port as the advertised BSR address, uses 30 bits as the hash-mask-length, and has a priority of 10.

```
Device(config)# interface gigabitethernet1/0/2
```

```
Device(config-if)# ip address 172.21.24.18 255.255.255.0
Device(config-if)# ip pim sparse-mode
Device(config-if)# ip pim bsr-candidate gigabitethernet1/0/2 30 10
```

### Related Topics

- [Configuring Candidate BSRs \(CLI\)](#), on page 550
- [PIMv2 Bootstrap Router](#), on page 526

## Example: Configuring Candidate RPs

This example shows how to configure the device to advertise itself as a candidate RP to the BSR in its PIM domain. Standard access list number 4 specifies the group prefix associated with the RP that has the address identified by a port. That RP is responsible for the groups with the prefix 239.

```
Device(config)# ip pim rp-candidate gigabitethernet1/0/2 group-list 4
Device(config)# access-list 4 permit 239.0.0.0 0.255.255.255
```

### Related Topics

- [Configuring the Candidate RPs \(CLI\)](#), on page 551
- [Rendezvous Points](#), on page 523

## Additional References

### Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	<i>IP Multicast Routing Command Reference (Catalyst 3850 Switches)</i>
IGMP Helper command syntax and usage information.	<i>IP Multicast Routing Command Reference (Catalyst 3850 Switches)</i>
Multicast Source Discovery Protocol (MSDP)	<i>IP Routing: Protocol-Independent Configuration Guide, Cisco IOS XE Release 3E (Catalyst 3850 Switches)</i>
Enhanced Interior Gateway Routing Protocol (EIGRP) stub routing	<i>IP Routing: EIGRP Configuration Guide, Cisco IOS XE Release 3E (Catalyst 3850 Switches)</i>
Open Shortest Path First (OSPF) stub routing	<i>IP Routing: OSPF Configuration Guide, Cisco IOS XE 3E (Catalyst 3850 Switches)</i>
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
Cisco IOS IP SLAs commands	<a href="#">Cisco IOS IP Multicast Command Reference</a>

**Error Message Decoder**

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**Standards and RFCs**

Standard/RFC	Title
PIM is defined in <a href="#">RFC 4601</a> and in these Internet Engineering Task Force (IETF) Internet drafts.	<ul style="list-style-type: none"> <li>• <i>Protocol Independent Multicast (PIM): Motivation and Architecture</i></li> <li>• <i>Protocol Independent Multicast (PIM), Dense Mode Protocol Specification</i></li> <li>• <i>Protocol Independent Multicast (PIM), Sparse Mode Protocol Specification</i></li> <li>• <i>draft-ietf-idmr-igmp-v2-06.txt, Internet Group Management Protocol, Version 2</i></li> <li>• <i>draft-ietf-pim-v2-dm-03.txt, PIM Version 2 Dense Mode</i></li> </ul>

**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for PIM

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.



## CHAPTER 32

# Configuring PIM MIB Extension for IP Multicast

- [Information About PIM MIB Extension for IP Multicast, on page 577](#)
- [How to Configure PIM MIB Extension for IP Multicast, on page 578](#)
- [Configuration Examples for PIM MIB Extensions, on page 579](#)
- [Additional References, on page 579](#)

## Information About PIM MIB Extension for IP Multicast

### PIM MIB Extensions for SNMP Traps for IP Multicast

Protocol Independent Multicast (PIM) is an IP multicast routing protocol used for routing multicast data packets to multicast groups. RFC 2934 defines the PIM MIB for IPv4, which describes managed objects that enable users to remotely monitor and configure PIM using Simple Network Management Protocol (SNMP).

PIM MIB extensions introduce the following new classes of PIM notifications:

- neighbor-change--This notification results from the following conditions:
  - A router's PIM interface is disabled or enabled (using the `ip pim` command in interface configuration mode)
  - A router's PIM neighbor adjacency expires (defined in RFC 2934)
- rp-mapping-change--This notification results from a change in the rendezvous point (RP) mapping information due to either Auto-RP messages or bootstrap router (BSR) messages.
- invalid-pim-message--This notification results from the following conditions:
  - An invalid (\*, G) Join or Prune message is received by the device (for example, when a router receives a Join or Prune message for which the RP specified in the packet is not the RP for the multicast group)
  - An invalid PIM register message is received by the device (for example, when a router receives a register message from a multicast group for which it is not the RP)

### Benefits of PIM MIB Extensions

PIM MIB extensions:

- Allow users to identify changes in the multicast topology of their network by detecting changes in the RP mapping.
- Provide traps to monitor the PIM protocol on PIM-enabled interfaces.
- Help users identify routing issues when multicast neighbor adjacencies expire on a multicast interface.
- Enable users to monitor RP configuration errors (for example, errors due to flapping in dynamic RP allocation protocols like Auto-RP).

## How to Configure PIM MIB Extension for IP Multicast

### Enabling PIM MIB Extensions for IP Multicast

Perform this task to enable PIM MIB extensions for IP multicast.



#### Note

- The `pimInterfaceVersion` object was removed from RFC 2934 and, therefore, is no longer supported in software.
- The following MIB tables are not supported in Cisco software:
  - `pimIpMRouteTable`
  - `pimIpMRouteNextHopTable`

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>snmp-server enable traps pim</b> <b>[neighbor-change   rp-mapping-change  </b> <b>invalid-pim-message]</b> <b>Example:</b> Device(config)# snmp-server enable traps pim neighbor-change	Enables a device to send PIM notifications. <ul style="list-style-type: none"> <li>• <b>neighbor-change</b> --This keyword enables notifications indicating when a device's PIM interface is disabled or enabled, or when a device's PIM neighbor adjacency expires.</li> <li>• <b>rp-mapping-change</b> --This keyword enables notifications indicating a change</li> </ul>



	Command or Action	Purpose
		<p>in RP mapping information due to either Auto-RP messages or BSR messages.</p> <ul style="list-style-type: none"> <li>• <b>invalid-pim-message</b> --This keyword enables notifications for monitoring invalid PIM protocol operations (for example, when a device receives a join or prune message for which the RP specified in the packet is not the RP for the multicast group or when a device receives a register message from a multicast group for which it is not the RP).</li> </ul>
<b>Step 4</b>	<p><b>snmp-server host</b> <i>host-address</i> [<b>traps   informs</b>] <i>community-string</i> <b>pim</b></p> <p><b>Example:</b></p> <pre>Device(config)# snmp-server host 10.10.10.10 traps public pim</pre>	Specifies the recipient of a PIM SNMP notification operation.

## Configuration Examples for PIM MIB Extensions

### Example Enabling PIM MIB Extensions for IP Multicast

The following example shows how to configure a router to generate notifications indicating that a PIM interface of the router has been enabled. The first line configures PIM traps to be sent as SNMP v2c traps to the host with IP address 10.0.0.1. The second line configures the router to send the neighbor-change class of trap notification to the host.

```
snmp-server host 10.0.0.1 traps version 2c public pim
snmp-server enable traps pim neighbor-change
interface ethernet0/0
 ip pim sparse-mode
```

## Additional References

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
IP multicast commands	<a href="#">Cisco IOS IP Multicast Command Reference</a>

**Standards and RFCs**

Standard/RFC	Title
draft-kouvelas-pim-bidir-new-00.txt	<a href="#">A New Proposal for Bi-directional PIM</a>
RFC 1112	<a href="#">Host Extensions for IP Multicasting</a>
RFC 1918	<a href="#">Address Allocation for Private Internets</a>
RFC 2770	<a href="#">GLOP Addressing in 233/8</a>
RFC 3569	<a href="#">An Overview of Source-Specific Multicast (SSM)</a>

**MIBs**

MIB	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>



## CHAPTER 33

# Configuring MSDP

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- [Additional References, on page 616](#)
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## Information About Using MSDP to Interconnect Multiple PIM-SM Domains

### Benefits of Using MSDP to Interconnect Multiple PIM-SM Domains

- Allows a rendezvous point (RP) to dynamically discover active sources outside of its domain.
- Introduces a more manageable approach for building multicast distribution trees between multiple domains.

MSDP is a mechanism to connect multiple PIM-SM domains. The purpose of MSDP is to discover multicast sources in other PIM domains. The main advantage of MSDP is that it reduces the complexity of interconnecting multiple PIM-SM domains by allowing PIM-SM domains to use an interdomain source tree (rather than a common shared tree). When MSDP is configured in a network, RPs exchange source information with RPs in other domains. An RP can join the interdomain source tree for sources that are sending to groups for which it has receivers. The RP can do that because it is the root of the shared tree within its domain, which has branches to all points in the domain where there are active receivers. When a last-hop device learns of a new source outside the PIM-SM domain (through the arrival of a multicast packet from the source down the shared tree), it then can send a join toward the source and join the interdomain source tree.



**Note** If the RP either has no shared tree for a particular group or a shared tree whose outgoing interface list is null, it does not send a join to the source in another domain.

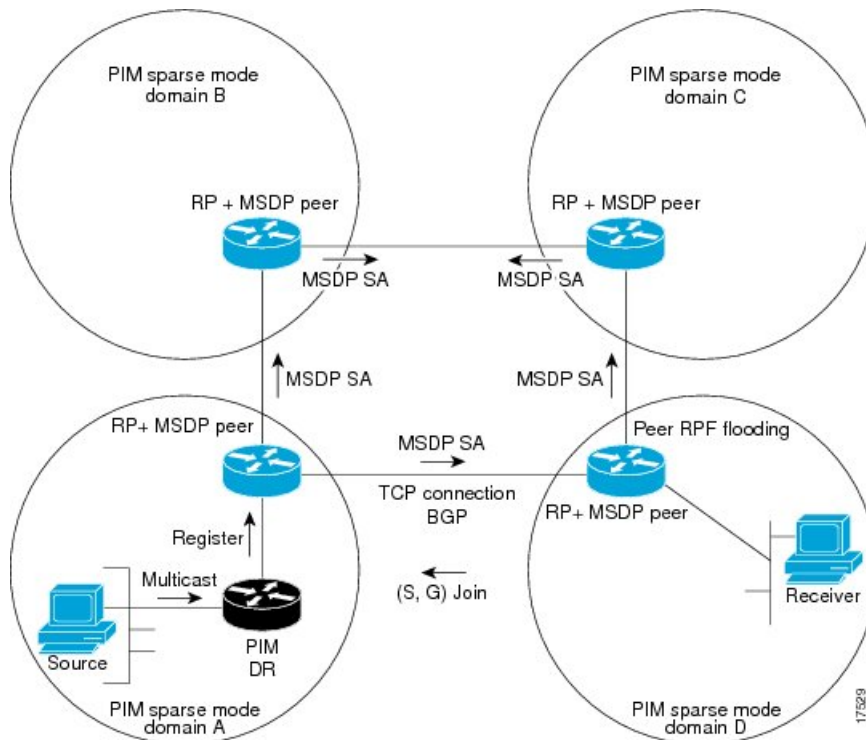
When MSDP is enabled, an RP in a PIM-SM domain maintains MSDP peering relationships with MSDP-enabled devices in other domains. This peering relationship occurs over a TCP connection, where primarily a list of sources sending to multicast groups is exchanged. MSDP uses TCP (port 639) for its peering connections. As with BGP, using point-to-point TCP peering means that each peer must be explicitly configured. The TCP connections between RPs, moreover, are achieved by the underlying routing system. The receiving RP uses the source lists to establish a source path. If the multicast sources are of interest to a domain that has receivers, multicast data is delivered over the normal, source-tree building mechanism provided by PIM-SM. MSDP is also used to announce sources sending to a group. These announcements must originate at the RP of the domain.

The figure illustrates MSDP operating between two MSDP peers. PIM uses MSDP as the standard mechanism to register a source with the RP of a domain.



**Note** Although the following illustration and example uses routers in the configuration, any device (router or switch) can be used.

**Figure 31: MSDP Running Between RP Peers**



When MSDP is implemented, the following sequence of events occurs:

1. When a PIM designated device (DR) registers a source with its RP as illustrated in the figure, the RP sends a Source-Active (SA) message to all of its MSDP peers.



**Note** The DR sends the encapsulated data to the RP only once per source (when the source goes active). If the source times out, this process happens again when it goes active again. This situation is different from the periodic SA message that contains all sources that are registered to the originating RP. Those SA messages are MSDP control packets, and, thus, do not contain encapsulated data from active sources.

1. The SA message identifies the source address, the group that the source is sending to, and the address or the originator ID of the RP, if configured.
2. Each MSDP peer that receives the SA message floods the SA message to all of its peers downstream from the originator. In some cases (such as the case with the RPs in PIM-SM domains B and C in the figure), an RP may receive a copy of an SA message from more than one MSDP peer. To prevent looping, the RP consults the BGP next-hop database to determine the next hop toward the originator of the SA message. If both MBGP and unicast BGP are configured, MBGP is checked first, and then unicast BGP. That next-hop neighbor is the RPF-peer for the originator. SA messages that are received from the originator on any interface other than the interface to the RPF peer are dropped. The SA message flooding process, therefore, is referred to as peer-RPF flooding. Because of the peer-RPF flooding mechanism, BGP or MBGP must be running in conjunction with MSDP.
1. When an RP receives an SA message, it checks to see whether there are any members of the advertised groups in its domain by checking to see whether there are interfaces on the group's (\*, G) outgoing interface list. If there are no group members, the RP does nothing. If there are group members, the RP sends an (S, G) join toward the source. As a result, a branch of the interdomain source tree is constructed across autonomous system boundaries to the RP. As multicast packets arrive at the RP, they are then forwarded down its own shared tree to the group members in the RP's domain. The members' DRs then have the option of joining the rendezvous point tree (RPT) to the source using standard PIM-SM procedures.
2. The originating RP continues to send periodic SA messages for the (S, G) state every 60 seconds for as long as the source is sending packets to the group. When an RP receives an SA message, it caches the SA message. Suppose, for example, that an RP receives an SA message for (172.16.5.4, 228.1.2.3) from originating RP 10.5.4.3. The RP consults its mroute table and finds that there are no active members for group 228.1.2.3, so it passes the SA message to its peers downstream of 10.5.4.3. If a host in the domain then sends a join to the RP for group 228.1.2.3, the RP adds the interface toward the host to the outgoing interface list of its (\*, 224.1.2.3) entry. Because the RP caches SA messages, the device will have an entry for (172.16.5.4, 228.1.2.3) and can join the source tree as soon as a host requests a join.



**Note** In all current and supported software releases, caching of MSDP SA messages is mandatory and cannot be manually enabled or disabled. By default, when an MSDP peer is configured, the **ip multicast cache-sa-state** command will automatically be added to the running configuration.

## MSDP Message Types

There are four basic MSDP message types, each encoded in their own Type, Length, and Value (TLV) data format.

## SA Messages

SA messages are used to advertise active sources in a domain. In addition, these SA messages may contain the initial multicast data packet that was sent by the source.

SA messages contain the IP address of the originating RP and one or more (S, G) pairs being advertised. In addition, the SA message may contain an encapsulated data packet.



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**Note** For more information about SA messages, see the [SA Message Origination Receipt and Processing](#), on page 584 section.

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## SA Request Messages

SA request messages are used to request a list of active sources for a specific group. These messages are sent to an MSDP SA cache that maintains a list of active (S, G) pairs in its SA cache. Join latency can be reduced by using SA request messages to request the list of active sources for a group instead of having to wait up to 60 seconds for all active sources in the group to be readvertised by originating RPs.

## SA Response Messages

SA response messages are sent by the MSDP peer in response to an SA request message. SA response messages contain the IP address of the originating RP and one or more (S, G) pairs of the active sources in the originating RP's domain that are stored in the cache.

## Keepalive Messages

Keepalive messages are sent every 60 seconds in order to keep the MSDP session active. If no keepalive messages or SA messages are received for 75 seconds, the MSDP session is reset.

## SA Message Origination Receipt and Processing

The section describes SA message origination, receipt, and processing in detail.

## SA Message Origination

SA messages are triggered by an RP (assuming MSDP is configured) when any new source goes active within a local PIM-SM domain. A local source is a source that is directly connected to the RP or is the first-hop DR that has registered with it. An RP originates SA messages only for local sources in its PIM-SM domain; that is, for local sources that register with it.



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**Note** A local source is denoted by the A flag being set in the (S, G) mroute entry on the RP (which can be viewed in the output of the **show ip mroute** command). This flag indicates that the source is a candidate for advertisement by the RP to other MSDP peers.

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When a source is in the local PIM-SM domain, it causes the creation of (S, G) state in the RP. New sources are detected by the RP either by the receipt of a register message or the arrival of the first (S, G) packet from a directly connected source. The initial multicast packet sent by the source (either encapsulated in the register message or received from a directly connected source) is encapsulated in the initial SA message.

## SA Message Receipt

SA messages are only accepted from the MSDP RPF peer that is in the best path back toward the originator. The same SA message arriving from other MSDP peers must be ignored or SA loops can occur.

Deterministically selecting the MSDP RPF peer for an arriving SA message requires knowledge of the MSDP topology. However, MSDP does not distribute topology information in the form of routing updates. MSDP infers this information by using (M)BGP routing data as the best approximation of the MSDP topology for the SA RPF check mechanism. An MSDP topology, therefore, must follow the same general topology as the BGP peer topology. Besides a few exceptions (such as default MSDP peers and MSDP peers in MSDP mesh groups), MSDP peers, in general should also be (M)BGP peers.

### How RPF Check Rules Are Applied to SA Messages

The rules that apply to RPF checks for SA messages are dependent on the BGP peerings between the MSDP peers:

- Rule 1: Applied when the sending MSDP peer is also an interior (M)BGP peer.
- Rule 2: Applied when the sending MSDP peer is also an exterior (M)BGP peer.
- Rule 3: Applied when the sending MSDP peer is not an (M)BGP peer.

RPF checks are not performed in the following cases:

- If the sending MSDP peer is the only MSDP peer, which would be the case if only a single MSDP peer or a default MSDP peer is configured.
- If the sending MSDP peer is a member of a mesh group.
- If the sending MSDP peer address is the RP address contained in the SA message.

### How the Software Determines the Rule to Apply to RPF Checks

The software uses the following logic to determine which RPF rule to apply to RPF checks:

- Find the (M)BGP neighbor that has the same IP address as the sending MSDP peer.
  - If the matching (M)BGP neighbor is an internal BGP (iBGP) peer, apply Rule 1.
  - If the matching (M)BGP neighbor is an external BGP (eBGP) peer, apply Rule 2.
  - If no match is found, apply Rule 3.

The implication of the RPF check rule selection is as follows: The IP address used to configure an MSDP peer on a device must match the IP address used to configure the (M)BGP peer on the same device.

### Rule 1 of RPF Checking of SA Messages in MSDP

Rule 1 of RPF checking in MSDP is applied when the sending MSDP peer is also an i(M)BGP peer. When Rule 1 is applied, the RPF check proceeds as follows:

1. The peer searches the BGP Multicast Routing Information Base (MRIB) for the best path to the RP that originated the SA message. If a path is not found in the MRIB, the peer then searches the Unicast Routing Information Base (URIB). If a path is still not found, the RPF check fails.
2. If the previous search succeeds (that is, the best path is found), the peer then determines the address of the BGP neighbor for this best path, which will be the address of the BGP neighbor that sent the peer the path in BGP update messages.




---

**Note** The BGP neighbor address is not the same as the next-hop address in the path. Because i(M)BGP peers do not update the next-hop attribute of a path, the next-hop address usually is not the same as the address of the BGP peer that sent us the path.

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**Note** The BGP neighbor address is not necessarily the same as the BGP ID of the peer that sent the peer the path.

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1. If the IP address of the sending MSDP peer is the same as the BGP neighbor address (that is, the address of the BGP peer that sent the peer the path), then the RPF check succeeds; otherwise it fails.

### Implications of Rule 1 of RPF Checking on MSDP

The MSDP topology must mirror the (M)BGP topology. In general, wherever there is an i(M)BGP peer connection between two devices, an MSDP peer connection should be configured. More specifically, the IP address of the far-end MSDP peer connection must be the same as the far-end i(M)BGP peer connection. The addresses must be the same because the BGP topology between i(M)BGP peers inside an autonomous system is not described by the AS path. If it were always the case that i(M)BGP peers updated the next-hop address in the path when sending an update to another i(M)BGP peer, then the peer could rely on the next-hop address to describe the i(M)BGP topology (and hence the MSDP topology). However, because the default behavior for i(M)BGP peers is to not update the next-hop address, the peer cannot rely on the next-hop address to describe the (M)BGP topology (MSDP topology). Instead, the i(M)BGP peer uses the address of the i(M)BGP peer that sent the path to describe the i(M)BGP topology (MSDP topology) inside the autonomous system.




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**Tip** Care should be taken when configuring the MSDP peer addresses to make sure that the same address is used for both i(M)BGP and MSDP peer addresses.

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### Rule 2 of RPF Checking of SA Messages in MSDP

Rule 2 of RPF checking in MSDP is applied when the sending MSDP peer is also an e(M)BGP peer. When Rule 2 is applied, the RPF check proceeds as follows:

1. The peer searches the BGP MRIB for the best path to the RP that originated the SA message. If a path is not found in the MRIB, the peer then searches the URIB. If a path is still not found, the RPF check fails.
2. If the previous search succeeds (that is, the best path is found), the peer then examines the path. If the first autonomous system in the best path to the RP is the same as the autonomous system of the e(M)BGP peer (which is also the sending MSDP peer), then the RPF check succeeds; otherwise it fails.

### Implications of Rule 2 of RPF Checking on MSDP

The MSDP topology must mirror the (M)BGP topology. In general, wherever there is an e(M)BGP peer connection between two devices, an MSDP peer connection should be configured. As opposed to Rule 1, the IP address of the far-end MSDP peer connection does not have to be the same as the far-end e(M)BGP peer connection. The reason that the addresses do not have to be identical is that BGP topology between two e(M)BGP peers is not described by the AS path.



### Rule 3 of RPF Checking of SA Messages in MSDP

Rule 3 of RPF checking is applied when the sending MSDP peer is not a (M)BGP peer at all. When Rule 3 is applied, the RPF check proceeds as follows:

1. The peer searches the BGP MRIB for the best path to the RP that originated the SA message. If a path is not found in the MRIB, the peer then searches the URIB. If a path is still not found, the RPF check fails.
2. If the previous search succeeds (that is, the best path to the RP that originated the SA message is found), the peer then searches the BGP MRIB for the best path to the MSDP peer that sent the SA message. If a path is not found in the MRIB, the peer then searches the URIB. If a path is still not found, the RPF check fails.



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**Note** The autonomous system of the MSDP peer that sent the SA is the origin autonomous system, which is the last autonomous system in the AS path to the MSDP peer.

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1. If the first autonomous system in the best path to the RP is the same as the autonomous system of the sending MSDP peer, then the RPF check succeeds; otherwise it fails.

## SA Message Processing

The following steps are taken by an MSDP peer whenever it processes an SA message:

1. Using the group address G of the (S, G) pair in the SA message, the peer locates the associated (\*, G) entry in the mroute table. If the (\*, G) entry is found and its outgoing interface list is not null, then there are active receivers in the PIM-SM domain for the source advertised in the SA message.
2. The MSDP peer then creates an (S, G) entry for the advertised source.
3. If the (S, G) entry did not already exist, the MSDP peer immediately triggers an (S, G) join toward the source in order to join the source tree.
4. The peer then floods the SA message to all other MSDP peers with the exception of:
  - The MSDP peer from which the SA message was received.
  - Any MSDP peers that are in the same MSDP mesh group as this device (if the peer is a member of a mesh group).



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**Note** SA messages are stored locally in the device's SA cache.

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## MSDP Peers

Like BGP, MSDP establishes neighbor relationships with other MSDP peers. MSDP peers connect using TCP port 639. The lower IP address peer takes the active role of opening the TCP connection. The higher IP address peer waits in LISTEN state for the other to make the connection. MSDP peers send keepalive messages every 60 seconds. The arrival of data performs the same function as the keepalive message and keeps the session from timing out. If no keepalive messages or data is received for 75 seconds, the TCP connection is reset.

## MSDP MD5 Password Authentication

The MSDP MD5 password authentication feature is an enhancement to support Message Digest 5 (MD5) signature protection on a TCP connection between two MSDP peers. This feature provides added security by protecting MSDP against the threat of spoofed TCP segments being introduced into the TCP connection stream.

### How MSDP MD5 Password Authentication Works

Developed in accordance with RFC 2385, the MSDP MD5 password authentication feature is used to verify each segment sent on the TCP connection between MSDP peers. The **ip msdp password peer** command is used to enable MD5 authentication for TCP connections between two MSDP peers. When MD5 authentication is enabled between two MSDP peers, each segment sent on the TCP connection between the peers is verified. MD5 authentication must be configured with the same password on both MSDP peers; otherwise, the connection between them will not be made. Configuring MD5 authentication causes the Cisco IOS software to generate and verify the MD5 digest of every segment sent on the TCP connection.

### Benefits of MSDP MD5 Password Authentication

- Protects MSDP against the threat of spoofed TCP segments being introduced into the TCP connection stream.
- Uses the industry-standard MD5 algorithm for improved reliability and security.

## SA Message Limits

The **ip msdp sa-limit** command is used to limit the overall number of SA messages that a device can accept from specified MSDP peers. When the **ip msdp sa-limit** command is configured, the device maintains a per-peer count of SA messages stored in the SA cache and will ignore new messages from a peer if the configured SA message limit for that peer has been reached.

The **ip msdp sa-limit** command was introduced as a means to protect an MSDP-enabled device from denial of service (DoS) attacks. We recommended that you configure SA message limits for all MSDP peerings on the device. An appropriately low SA limit should be configured on peerings with a stub MSDP region (for example, a peer that may have some further downstream peers but that will not act as a transit for SA messages across the rest of the Internet). A high SA limit should be configured for all MSDP peerings that act as transits for SA messages across the Internet.

## MSDP Keepalive and Hold-Time Intervals

The **ip msdp keepalive** command is used to adjust the interval at which an MSDP peer will send keepalive messages and the interval at which the MSDP peer will wait for keepalive messages from other peers before declaring them down.

Once an MSDP peering session is established, each side of the connection sends a keepalive message and sets a keepalive timer. If the keepalive timer expires, the local MSDP peer sends a keepalive message and restarts its keepalive timer; this interval is referred to as the keepalive interval. The *keepalive-interval* argument is used to adjust the interval for which keepalive messages will be sent. The keepalive timer is set to the value specified for the *keepalive-interval* argument when the peer comes up. The keepalive timer is reset to the value of the *keepalive-interval* argument whenever an MSDP keepalive message is sent to the peer and reset when

the timer expires. The keepalive timer is deleted when an MSDP peering session is closed. By default, the keepalive timer is set to 60 seconds.



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**Note** The value specified for the *keepalive-interval* argument must be less than the value specified for the *hold-time-interval* argument and must be at least one second.

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The hold-time timer is initialized to the value of the *hold-time-interval* argument whenever an MSDP peering connection is established, and is reset to the value of the *hold-time-interval* argument whenever an MSDP keepalive message is received. The hold-time timer is deleted whenever an MSDP peering connection is closed. By default, the hold-time interval is set to 75 seconds.

Use the *hold-time-interval* argument to adjust the interval at which the MSDP peer will wait for keepalive messages from other peers before declaring them down.

## MSDP Connection-Retry Interval

You can adjust the interval at which all MSDP peers will wait after peering sessions are reset before attempting to reestablish the peering sessions. This interval is referred to as the connection-retry interval. By default, MSDP peers will wait 30 seconds after the session is reset before attempting to reestablish sessions with other peers. The modified configured connection-retry interval applies to all MSDP peering sessions on the device.

## Default MSDP Peers

A stub autonomous system also might want to have MSDP peerings with more than one RP for the sake of redundancy. For example, SA messages cannot just be accepted from multiple default peers, because there is no RPF check mechanism. Instead, SA messages are accepted from only one peer. If that peer fails, SA messages are then accepted from the other peer. The underlying assumption here, of course, is that both default peers are sending the same SA messages.

The figure illustrates a scenario where default MSDP peers might be used. In the figure, a customer that owns Device B is connected to the Internet through two Internet service providers (ISPs), one that owns Device A and the other that owns Device C. They are not running BGP or MBGP between them. In order for the customer to learn about sources in the ISP domain or in other domains, Device B identifies Device A as its default MSDP peer. Device B advertises SA messages to both Device A and Device C, but accepts SA messages either from Device A only or Device C only. If Device A is the first default peer in the configuration, it will be used if it is up and running. Only if Device A is not running will Device B accept SA messages from Device C.

The ISP will also likely use a prefix list to define which prefixes it will accept from the customer device. The customer will define multiple default peers, each having one or more prefixes associated with it.

The customer has two ISPs to use. The customer defines both ISPs as default peers. As long as the first default peer identified in the configuration is up and running, it will be the default peer and the customer will accept all SA messages it receives from that peer.

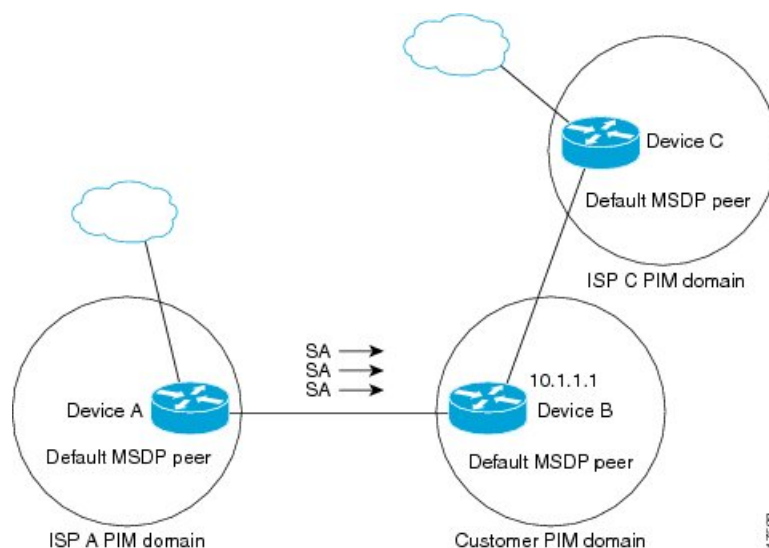


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**Note** Although the following illustration and example uses routers in the configuration, any device (router or switch) can be used.

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Figure 32: Default MSDP Peer Scenario



Device B advertises SAs to Device A and Device C, but uses only Device A or Device C to accept SA messages. If Device A is first in the configuration, it will be used if it is up and running. Only when Device A is not running will Device B accept SAs from Device C. This is the behavior without a prefix list.

If you specify a prefix list, the peer will be a default peer only for the prefixes in the list. You can have multiple active default peers when you have a prefix list associated with each. When you do not have any prefix lists, you can configure multiple default peers, but only the first one is the active default peer as long as the device has connectivity to this peer and the peer is alive. If the first configured peer goes down or the connectivity to this peer goes down, the second configured peer becomes the active default, and so on.

## MSDP Mesh Groups

An MSDP mesh group is a group of MSDP speakers that have fully meshed MSDP connectivity between one another. In other words, each of the MSDP peers in the group must have an MSDP peering relationship (MSDP connection) to every other MSDP peer in the group. When an MSDP mesh group is configured between a group of MSDP peers, SA message flooding is reduced. Because when an MSDP peer in the group receives an SA message from another MSDP peer in the group, it assumes that this SA message was sent to all the other MSDP peers in the group. As a result, it is not necessary for the receiving MSDP peer to flood the SA message to the other MSDP peers in the group.

### Benefits of MSDP Mesh Groups

- Optimizes SA flooding--MSDP mesh groups are particularly useful for optimizing SA flooding when two or more peers are in a group.
- Reduces the amount of SA traffic across the Internet--When MSDP mesh groups are used, SA messages are not flooded to other mesh group peers.
- Eliminates RPF checks on arriving SA messages--When an MSDP mesh group is configured, SA messages are always accepted from mesh group peers.

## SA Origination Filters

By default, an RP that is configured to run MSDP will originate SA messages for all local sources for which it is the RP. Local sources that register with an RP, therefore, will be advertised in SA messages, which in some cases is not desirable. For example, if sources inside a PIM-SM domain are using private addresses (for example, network 10.0.0.0/8), you should configure an SA origination filter to restrict those addresses from being advertised to other MSDP peers across the Internet.

To control what sources are advertised in SA messages, you can configure SA origination filters on an RP. By creating SA origination filters, you can control the sources advertised in SA messages as follows:

- You can configure an RP to prevent the device from advertising local sources in SA messages. The device will still forward SA messages from other MSDP peers in the normal fashion; it will just not originate any SA messages for local sources.
- You can configure the device to only originate SA messages for local sources sending to specific groups that match (S, G) pairs defined in the extended access list. All other local sources will not be advertised in SA messages.
- You can configure the device to only originate SA messages for local sources sending to specific groups that the match AS paths defined in an AS-path access list. All other local sources will not be advertised in SA messages.
- You can configure the device to only originate SA messages for local sources that match the criteria defined in the route map. All other local sources will not be advertised in SA messages.
- You configure an SA origination filter that includes an extended access list, an AS-path access list, and route map, or a combination thereof. In this case, all conditions must be true before any local sources are advertised in SA messages.

## Use of Outgoing Filter Lists in MSDP

By default, an MSDP-enabled device forwards all SA messages it receives to all of its MSDP peers. However, you can prevent SA messages from being forwarded to MSDP peers by creating outgoing filter lists. Outgoing filter lists apply to all SA messages, whether locally originated or received from another MSDP peer, whereas SA origination filters apply only to locally originated SA messages. For more information about enabling a filter for MSDP SA messages originated by the local device, see the [Controlling SA Messages Originated by an RP for Local Sources](#) section.

By creating an outgoing filter list, you can control the SA messages that a device forwards to a peer as follows:

- You can filter all outgoing SA messages forwarded to a specified MSDP peer by configuring the device to stop forwarding its SA messages to the MSDP peer.
- You can filter a subset of outgoing SA messages forwarded to a specified MSDP peer based on (S, G) pairs defined in an extended access list by configuring the device to only forward SA messages to the MSDP peer that match the (S, G) pairs permitted in an extended access list. The forwarding of all other SA messages to the MSDP peer will be stopped.
- You can filter a subset of outgoing SA messages forwarded to a specified MSDP peer based on match criteria defined in a route map by configuring the device to only forward SA messages that match the criteria defined in the route map. The forwarding of all other SA messages to the MSDP peer will be stopped.

- You can filter a subset of outgoing SA messages from a specified peer based on the announcing RP address contained in the SA message by configuring the device to filter outgoing SA messages based on their origin, even after an SA message has been transmitted across one or more MSDP peers. The forwarding of all other SA messages to the MSDP peer will be stopped.
- You can configure an outgoing filter list that includes an extended access list, a route map, and either an RP access list or an RP route map. In this case, all conditions must be true for the MSDP peer to forward the outgoing SA message.

**Caution**

Arbitrary filtering of SA messages can result in downstream MSDP peers being starved of SA messages for legitimate active sources. Care, therefore, should be taken when using these sorts of filters. Normally, outgoing filter lists are used only to reject undesirable sources, such as sources using private addresses.

## Use of Incoming Filter Lists in MSDP

By default, an MSDP-enabled device receives all SA messages sent to it from its MSDP peers. However, you can control the source information that a device receives from its MSDP peers by creating incoming filter lists.

By creating incoming filter lists, you can control the incoming SA messages that a device receives from its peers as follows:

- You can filter all incoming SA messages from a specified MSDP peer by configuring the device to ignore all SA messages sent to it from the specified MSDP peer.
- You can filter a subset of incoming SA messages from a specified peer based on (S, G) pairs defined in an extended access list by configuring the device to only receive SA messages from the MSDP peer that match the (S, G) pairs defined in the extended access list. All other incoming SA messages from the MSDP peer will be ignored.
- You can filter a subset of incoming SA request messages from a specified peer based on match criteria defined in a route map by configuring the device to only receive SA messages that match the criteria defined in the route map. All other incoming SA messages from the MSDP peer will be ignored.
- You can filter a subset of incoming SA messages from a specified peer based on both (S, G) pairs defined in an extended access list and on match criteria defined in a route map by configuring the device to only receive incoming SA messages that both match the (S, G) pairs defined in the extended access list and match the criteria defined in the route map. All other incoming SA messages from the MSDP peer will be ignored.
- You can filter a subset of incoming SA messages from a specified peer based on the announcing RP address contained in the SA message by configuring the device to filter incoming SA messages based on their origin, even after the SA message may have already been transmitted across one or more MSDP peers.
- You can configure an incoming filter list that includes an extended access list, a route map, and either an RP access list or an RP route map. In this case, all conditions must be true for the MSDP peer to receive the incoming SA message.

**Caution**

Arbitrary filtering of SA messages can result in downstream MSDP peers being starved of SA messages for legitimate active sources. Care, therefore, should be taken when using these sorts of filters. Normally, incoming filter lists are used only to reject undesirable sources, such as sources using private addresses.

## TTL Thresholds in MSDP

The time-to-live (TTL) value provides a means to limit the number of hops a packet can take before being dropped. The **ip multicast ttl-threshold** command is used to specify a TTL for data-encapsulated SA messages sent to specified MSDP peers. By default, multicast data packets in SA messages are sent to an MSDP peer, provided the TTL value of the packet is greater than 0, which is standard TTL behavior.

In general, a TTL-threshold problem can be introduced by the encapsulation of a source's initial multicast packet in an SA message. Because the multicast packet is encapsulated inside of the unicast SA message (whose TTL is 255), its TTL is not decremented as the SA message travels to the MSDP peer. Furthermore, the total number of hops that the SA message traverses can be drastically different than a normal multicast packet because multicast and unicast traffic may follow completely different paths to the MSDP peer and hence the remote PIM-SM domain. As a result, encapsulated packets can end up violating TTL thresholds. The solution to this problem is to configure a TTL threshold that is associated with any multicast packet that is encapsulated in an SA message sent to a particular MSDP peer using the **ip multicast ttl-threshold** command. The **ip msdp ttl-threshold** command prevents any multicast packet whose TTL in the IP header is less than the TTL value specified for the *ttl-value* argument from being encapsulated in SA messages sent to that peer.

## SA Request Messages

You can configure a noncaching device to send SA request messages to one or more specified MSDP peers.

If a noncaching RP has an MSDP peer that is caching SAs, you can reduce the join latency for a noncaching peer by enabling the noncaching peer to send SA request messages. When a host requests a join to a particular group, the noncaching RP sends an SA request message to its caching peers. If a peer has cached source information for the group in question, it sends the information to the requesting RP with an SA response message. The requesting RP uses the information in the SA response but does not forward the message to any other peers. If a noncaching RP receives an SA request, it sends an error message back to the requestor.

**Note**

In all current and supported software releases, caching of MSDP SA messages is mandatory and cannot be manually enabled or disabled. By default, when an MSDP peer is configured, the configured commands are automatically added to the running configuration.

## SA Request Filters

By default, a device honors all outgoing SA request messages from its MSDP peers; that is, it sends cached source information to requesting MSDP peers in SA response messages. You can control the outgoing SA request messages that a device will honor from specified peers by creating an SA request filter. An SA request filter controls the outgoing SA requests that the device will honor from MSDP peers as follows:

- You can filter all SA request messages from a specified peer by configuring the device to ignore all SA requests from the specified MSDP peer.

- You can filter a subset of SA request messages from a specified peer based on groups defined in a standard access list by configuring the device to honor only SA request messages from the MSDP peer that match the groups defined in a standard access list. SA request messages from the specified peer for other groups will be ignored.

## How to Use MSDP to Interconnect Multiple PIM-SM Domains

The first task is required; all other tasks are optional.

### Configuring an MSDP Peer



**Note** By enabling an MSDP peer, you implicitly enable MSDP.

#### Before you begin

- IP multicast routing must be enabled and PIM-SM must be configured.
- With the exception of a single MSDP peer, default MSDP peer, and MSDP mesh group scenarios, all MSDP peers must be configured to run BGP prior to being configured for MSDP.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp peer</b> <i>{peer-name peer-address}</i> <i>[connect-source type number]</i> <b>[remote-as as-number]</b> <b>Example:</b> Device(config)# ip msdp peer 192.168.1.2 connect-source loopback0	Enables MSDP and configures an MSDP peer as specified by the DNS name or IP address. <p><b>Note</b> The device that is selected to be configured as an MSDP peer is also usually a BGP neighbor. If it is not, see the <a href="#">Configuring a Default MSDP Peer, on page 600</a> section or the <a href="#">Configuring an MSDP Mesh Group, on page 601</a> section.</p>



	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>If you specify the <b>connect-source</b> keyword, the primary address of the specified local interface <i>type</i> and <i>number</i> values are used as the source IP address for the TCP connection. The <b>connect-source</b> keyword is recommended, especially for MSDP peers on a border that peer with a device inside of a remote domain.</li> </ul>
<b>Step 4</b>	<b>ip msdp description</b> <i>{peer-name peer-address}</i> <i>text</i>  <b>Example:</b>  <pre>Device(config)# ip msdp description 192.168.1.2 router at customer a</pre>	(Optional) Configures a description for a specified peer to make it easier to identify in a configuration or in <b>show</b> command output.
<b>Step 5</b>	<b>end</b>  <b>Example:</b>  <pre>Device(config)# end</pre>	Exits global configuration mode and returns to privileged EXEC mode.

## Shutting Down an MSDP Peer

Perform this optional task to shut down an MSDP peer.

If you are configuring several MSDP peers and you do not want any of the peers to go active until you have finished configuring all of them, you can shut down each peer, configure each peer, and later bring each peer up. You might also want to shut down an MSDP session without losing the configuration for that MSDP peer.



**Note** When an MSDP peer is shut down, the TCP connection is terminated and not restarted until the peer is brought back up using the **no ip msdp shutdown** command (for the specified peer).

### Before you begin

MSDP is running and the MSDP peers must be configured.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp shutdown</b> {peer-name   peer-address} <b>Example:</b>  Device(config)# ip msdp shutdown 192.168.1.3	Administratively shuts down the specified MSDP peer.
<b>Step 4</b>	Repeat Step 3 to shut down additional MSDP peers.	--
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config)# end	Exits global configuration mode and returns to privileged EXEC mode.

## Configuring MSDP MD5 Password Authentication Between MSDP Peers

Perform this optional task to configure MSDP MD5 password authentication between MSDP peers.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp password peer</b> {peer-name   peer-address} [encryption-type] string <b>Example:</b>  Device(config)# ip msdp password peer 10.32.43.144 0 test	Enables MD5 password encryption for a TCP connection between two MSDP peers. <p><b>Note</b> MD5 authentication must be configured with the same password on both MSDP peers; otherwise, the connection between them will not be made.</p> <ul style="list-style-type: none"> <li>• If you configure or change the password or key, which is used for MD5</li> </ul>

	Command or Action	Purpose
		authentication between two MSDP peers, the local device does not disconnect the existing session after you configure the password. You must manually disconnect the session to activate the new or changed password.
<b>Step 4</b>	<b>exit</b> <b>Example:</b> <pre>Device(config)# exit</pre>	Exits global configuration mode and returns to privileged EXEC mode.
<b>Step 5</b>	<b>show ip msdp peer</b> [peer-address   peer-name] <b>Example:</b> <pre>Device# show ip msdp peer</pre>	(Optional) Displays detailed information about MSDP peers. <b>Note</b> Use this command to verify whether MD5 password authentication is enabled on an MSDP peer.

## Troubleshooting Tips

If a device has a password configured for an MSDP peer but the MSDP peer does not, a message such as the following will appear on the console while the devices attempt to establish an MSDP session between them:

```
%TCP-6-BADAUTH: No MD5 digest from [peer's IP address]:11003 to [local router's IP address]:179
```

Similarly, if the two devices have different passwords configured, a message such as the following will appear on the console:

```
%TCP-6-BADAUTH: Invalid MD5 digest from [peer's IP address]:11004 to [local router's IP address]:179
```

The **debug ip tcp transactions** command is used to display information on significant TCP transactions such as state changes, retransmissions, and duplicate packets. In the context of monitoring or troubleshooting MSDP MD5 password authentication, use the **debug ip tcp transactions** command to verify that the MD5 password is enabled and that the keepalive message is received by the MSDP peer.

## Preventing DoS Attacks by Limiting the Number of SA Messages Allowed in the SA Cache from Specified MSDP Peers

Perform this optional (but highly recommended) task to limit the overall number of SA messages that the device can accept from specified MSDP peers. Performing this task protects an MSDP-enabled device from distributed denial-of-service (DoS) attacks.



**Note** We recommend that you perform this task for all MSDP peerings on the device.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp sa-limit</b> <i>{peer-address   peer-name}</i> <i>sa-limit</i> <b>Example:</b> <pre>Device(config)# ip msdp sa-limit 192.168.10.1 100</pre>	Limits the number of SA messages allowed in the SA cache from the specified MSDP.
<b>Step 4</b>	Repeat Step 3 to configure SA limits for additional MSDP peers.	--
<b>Step 5</b>	<b>exit</b> <b>Example:</b> <pre>Device(config)# exit</pre>	Exits global configuration mode and returns to privileged EXEC mode.
<b>Step 6</b>	<b>show ip msdp count</b> <i>[as-number]</i> <b>Example:</b> <pre>Device# show ip msdp count</pre>	(Optional) Displays the number of sources and groups originated in MSDP SA messages and the number of SA messages from an MSDP peer in the SA cache.
<b>Step 7</b>	<b>show ip msdp peer</b> <i>[peer-address   peer-name]</i> <b>Example:</b> <pre>Device# show ip msdp peer</pre>	(Optional) Displays detailed information about MSDP peers. <b>Note</b> The output of this command displays the number of SA messages received from MSDP peers that are stored in the cache.
<b>Step 8</b>	<b>show ip msdp summary</b> <b>Example:</b> <pre>Device# show ip msdp summary</pre>	(Optional) Displays MSDP peer status. <b>Note</b> The output of this command displays a per-peer "SA Count" field that displays the number of SAs stored in the cache.

## Adjusting the MSDP Keepalive and Hold-Time Intervals

Perform this optional task to adjust the interval at which an MSDP peer will send keepalive messages and the interval at which the MSDP peer will wait for keepalive messages from other peers before declaring them down. By default, it may take as long as 75 seconds for an MSDP peer to detect that a peering session with another MSDP peer has gone down. In network environments with redundant MSDP peers, decreasing the hold-time interval can expedite the reconvergence time of MSDP peers in the event that an MSDP peer fails.



**Note** We recommend that you do not change the command defaults for the **ip msdp keepalive** command, because the command defaults are in accordance with RFC 3618, *Multicast Source Discovery Protocol*. If your network environment requires that you modify the defaults, you must configure the same time values for the *keepalive-interval* and *hold-time-interval* arguments on both ends of the MSDP peering session.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp keepalive</b> {peer-address   peer-name} <i>keepalive-interval hold-time-interval</i> <b>Example:</b>  Device(config)# ip msdp keepalive 10.1.1.3 40 55	Configures the interval at which an MSDP peer will send keepalive messages and the interval at which the MSDP peer will wait for keepalive messages from other peers before declaring them down.
<b>Step 4</b>	Repeat Step 3 to adjust the keepalive message interval for additional MSDP peers.	--
<b>Step 5</b>	<b>exit</b> <b>Example:</b>  Device(config)# exit	Exits global configuration mode and returns to privileged EXEC mode.

## Adjusting the MSDP Connection-Retry Interval

Perform this optional task to adjust the interval at which MSDP peers will wait after peering sessions are reset before attempting to reestablish the peering sessions. In network environments where fast recovery of SA messages is required, such as in trading floor network environments, you may want to decrease the connection-retry interval to a time value less than the default value of 30 seconds.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp timer <i>connection-retry-interval</i></b> <b>Example:</b> Device# ip msdp timer 45	Configures the interval at which MSDP peers will wait after peering sessions are reset before attempting to reestablish the peering sessions.
<b>Step 4</b>	<b>exit</b> <b>Example:</b> Device(config)# exit	Exits global configuration mode and returns to privileged EXEC mode.

## Configuring a Default MSDP Peer

Perform this optional task to configure a default MSDP peer.

**Before you begin**

An MSDP default peer must be a previously configured MSDP peer. Before configuring a default MSDP peer, you must first configure an MSDP peer.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>ip msdp default-peer</b> <i>{peer-address   peer-name}</i> [ <b>prefix-list</b> <i>list</i> ]  <b>Example:</b>  Device(config)# ip msdp default-peer 192.168.1.3	Configures a default peer from which to accept all MSDP SA messages
<b>Step 4</b>	<b>exit</b>  <b>Example:</b>  Device(config)# exit	Exits global configuration mode and returns to privileged EXEC mode.

## Configuring an MSDP Mesh Group

Perform this optional task to configure an MSDP mesh group.



**Note** You can configure multiple mesh groups per device.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp mesh-group</b> <i>mesh-name</i> <i>{peer-address   peer-name}</i>  <b>Example:</b>  Device(config)# ip msdp mesh-group peermesh	Configures an MSDP mesh group and indicates that an MSDP peer belongs to that mesh group. <p><b>Note</b> All MSDP peers on a device that participate in a mesh group must be fully meshed with all other MSDP peers in the group. Each MSDP peer on each device must be configured as a peer using the <b>ip msdp peer</b> command and also as a member of the mesh group using the <b>ip msdp mesh-group</b> command.</p>

	Command or Action	Purpose
<b>Step 4</b>	Repeat Step 3 to add MSDP peers as members of the mesh group.	--
<b>Step 5</b>	<b>exit</b> <b>Example:</b> <pre>Device(config)# exit</pre>	Exits global configuration mode and returns to privileged EXEC mode.

## Controlling SA Messages Originated by an RP for Local Sources

Perform this task to control SA messages originated by an RP by enabling a filter to restrict which registered sources are advertised in SA messages.



**Note** For best practice information related to configuring MSDP SA message filters, see the [Multicast Source Discovery Protocol SA Filter Recommendations](#) tech note.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp redistribute [list access-list] [asn as-access-list] [route-map map-name]</b> <b>Example:</b> <pre>Device(config)# ip msdp redistribute route-map customer-sources</pre>	Enables a filter for MSDP SA messages originated by the local device. <p><b>Note</b> The <b>ip msdp redistribute</b> command can also be used to advertise sources that are known to the RP but not registered. However, it is strongly recommended that you not originate advertisements for sources that have not registered with the RP.</p>
<b>Step 4</b>	<b>exit</b> <b>Example:</b> <pre>Device(config)# exit</pre>	Exits global configuration mode and returns to privileged EXEC mode.



## Controlling the Forwarding of SA Messages to MSDP Peers Using Outgoing Filter Lists

Perform this optional task to control the forwarding of SA messages to MSDP peers by configuring outgoing filter lists.



**Note** For best practice information related to configuring MSDP SA message filters, see the [Multicast Source Discovery Protocol SA Filter Recommendations](#) tech note.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp sa-filter out</b> <i>{peer-address   peer-name}</i> [ <i>list access-list</i> ] [ <i>route-map map-name</i> ] [ <i>rp-list access-list</i> ] [ <i>rp-route-map map-name</i> ] <b>Example:</b> Device(config)# ip msdp sa-filter out 192.168.1.5 peerone	Enables a filter for outgoing MSDP messages.
<b>Step 4</b>	Repeat Step 3 to configure outgoing filter lists for additional MSDP peers.	--
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config)# exit	Exits global configuration mode and returns to privileged EXEC mode.

## Controlling the Receipt of SA Messages from MSDP Peers Using Incoming Filter Lists

Perform this optional task to control the receipt of incoming SA messages from MSDP peers.



**Note** For best practice information related to configuring MSDP SA message filters, see the [Multicast Source Discovery Protocol SA Filter Recommendations](#) tech note.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp sa-filter in</b> <i>{peer-address   peer-name}</i> [ <b>list</b> <i>access-list</i> ] [ <b>route-map</b> <i>map-name</i> ] [ <b>rp-list</b> <i>access-list</i>   <b>rp-route-map</b> <i>map-name</i> ] <b>Example:</b> Device(config)# ip msdp sa-filter in 192.168.1.3	Enables a filter for incoming MSDP SA messages.
<b>Step 4</b>	Repeat Step 3 to configure incoming filter lists for additional MSDP peers.	--
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config)# exit	Exits global configuration mode and returns to privileged EXEC mode.

## Using TTL Thresholds to Limit the Multicast Data Sent in SA Messages

Perform this optional task to establish a time to live (TTL) threshold to limit the multicast data sent in SA messages.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp ttl-threshold</b> {peer-address   peer-name} ttl-value <b>Example:</b>  <b>Example:</b>  Device(config)# ip msdp ttl-threshold 192.168.1.5 8	Sets a TTL value for MSDP messages originated by the local device. <ul style="list-style-type: none"> <li>By default, multicast data packets in SA messages are sent to an MSDP peer, provided the TTL value of the packet is greater than 0, which is standard TTL behavior.</li> </ul>
<b>Step 4</b>	<b>exit</b> <b>Example:</b>  Device(config)# exit	Exits global configuration mode and returns to privileged EXEC mode.

## Requesting Source Information from MSDP Peers

Perform this optional task to enable a device to request source information from MSDP peers.



**Note** Because SA caching is enabled by default and cannot be explicitly enabled or disabled in earlier Cisco software releases, performing this task is seldom needed.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp sa-request</b> {peer-address   peer-name} <b>Example:</b>	Specifies that the device send SA request messages to the specified MSDP peer.

	Command or Action	Purpose
	Device(config)# ip msdp sa-request 192.168.10.1	
<b>Step 4</b>	Repeat Step 3 to specify that the device send SA request messages to additional MSDP caching peers.	--
<b>Step 5</b>	<b>exit</b> <b>Example:</b>  Device(config)# exit	Exits global configuration mode and returns to privileged EXEC mode.

## Controlling the Response to Outgoing SA Request Messages from MSDP Peers Using SA Request Filters

Perform this optional task to control the outgoing SA request messages that the device will honor from MSDP peers.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp filter-sa-request</b> { <i>peer-address</i>   <i>peer-name</i> } [ <b>list</b> <i>access-list</i> ] <b>Example:</b>  Device(config)# ip msdp filter sa-request 172.31.2.2 list 1	Enables a filter for outgoing SA request messages.  <b>Note</b> Only one SA request filter can be configured per MSDP peer.
<b>Step 4</b>	Repeat Step 3 to configure SA request filters for additional MSDP peers.	--
<b>Step 5</b>	<b>exit</b> <b>Example:</b>  Device(config)# exit	Exits global configuration mode and returns to privileged EXEC mode.

## Including a Bordering PIM Dense Mode Region in MSDP

Perform this optional task to configure a border device to send SA messages for sources active in a PIM dense mode (PIM-DM) region.

You can have a device that borders a PIM-SM region and a PIM-DM region. By default, sources in the PIM-DM domain are not included in MSDP. You can configure this border device to send SA messages for sources active in the PIM-DM domain. If you do so, it is very important to also configure the **ip msdp redistribute** command to control what local sources from the PIM-DM domain are advertised. Not configuring this command can result in the (S, G) state remaining long after a source in the PIM-DM domain has stopped sending. For configuration information, see the [Controlling SA Messages Originated by an RP for Local Sources, on page 602](#) section.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp border sa-address</b> <i>type number</i> <b>Example:</b>  Device(config)# ip msdp border sa-address gigabitethernet0/0/0	Configures the device on the border between a PIM-SM and PIM-DM domain to originate SA messages for active sources in the PIM-DM domain.  • The IP address of the interface is used as the originator ID, which is the RP field in the SA message.
<b>Step 4</b>	<b>exit</b> <b>Example:</b>  Device(config)# exit	Exits global configuration mode and returns to privileged EXEC mode.

## Configuring an Originating Address Other Than the RP Address

Perform this optional task to allow an MSDP speaker that originates an SA message to use the IP address of its interface as the RP address in the SA message.

You can also change the originator ID for any one of the following reasons:

- If you configure multiple devices in an MSDP mesh group for Anycast RP.

- If you have a device that borders a PIM-SM domain and a PIM-DM domain. If a device borders a PIM-SM domain and a PIM-DM domain and you want to advertise active sources within the PIM-DM domain, configure the RP address in SA messages to be the address of the originating device's interface.

### Before you begin

MSDP is enabled and the MSDP peers are configured. For more information about configuring MSDP peers, see the [Configuring an MSDP Peer, on page 594](#) section.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp originator-id <i>type number</i></b> <b>Example:</b> Device(config)# ip msdp originator-id ethernet 1	Configures the RP address in SA messages to be the address of the originating device's interface.
<b>Step 4</b>	<b>exit</b> <b>Example:</b> Device(config)# exit	Exits global configuration mode and returns to privileged EXEC mode.

## Monitoring MSDP

Perform this optional task to monitor MSDP SA messages, peers, state, and peer status.

### Procedure

#### Step 1

**enable**

**Example:**

Device# **enable**

Enables privileged EXEC mode.

- Enter your password if prompted.

**Step 2** `debug ip msdp [peer-address | peer-name] [detail] [routes]`

Use this command to debug MSDP activity.

Use the optional *peer-address* or *peer-name* argument to specify for which peer debug events are logged.

The following is sample output from the `debug ip msdp` command:

**Example:**

```
Device# debug ip msdp
MSDP debugging is on
Device#
MSDP: 224.150.44.254: Received 1388-byte message from peer
MSDP: 224.150.44.254: SA TLV, len: 1388, ec: 115, RP: 172.31.3.92
MSDP: 224.150.44.254: Peer RPF check passed for 172.31.3.92, used EMBGP peer
MSDP: 224.150.44.250: Forward 1388-byte SA to peer
MSDP: 224.150.44.254: Received 1028-byte message from peer
MSDP: 224.150.44.254: SA TLV, len: 1028, ec: 85, RP: 172.31.3.92
MSDP: 224.150.44.254: Peer RPF check passed for 172.31.3.92, used EMBGP peer
MSDP: 224.150.44.250: Forward 1028-byte SA to peer
MSDP: 224.150.44.254: Received 1388-byte message from peer
MSDP: 224.150.44.254: SA TLV, len: 1388, ec: 115, RP: 172.31.3.111
MSDP: 224.150.44.254: Peer RPF check passed for 172.31.3.111, used EMBGP peer
MSDP: 224.150.44.250: Forward 1388-byte SA to peer
MSDP: 224.150.44.250: Received 56-byte message from peer
MSDP: 224.150.44.250: SA TLV, len: 56, ec: 4, RP: 192.168.76.241
MSDP: 224.150.44.250: Peer RPF check passed for 192.168.76.241, used EMBGP peer
MSDP: 224.150.44.254: Forward 56-byte SA to peer
MSDP: 224.150.44.254: Received 116-byte message from peer
MSDP: 224.150.44.254: SA TLV, len: 116, ec: 9, RP: 172.31.3.111
MSDP: 224.150.44.254: Peer RPF check passed for 172.31.3.111, used EMBGP peer
MSDP: 224.150.44.250: Forward 116-byte SA to peer
MSDP: 224.150.44.254: Received 32-byte message from peer
MSDP: 224.150.44.254: SA TLV, len: 32, ec: 2, RP: 172.31.3.78
MSDP: 224.150.44.254: Peer RPF check passed for 172.31.3.78, used EMBGP peer
MSDP: 224.150.44.250: Forward 32-byte SA to peer
```

**Step 3** `debug ip msdp resets`

Use this command to debug MSDP peer reset reasons.

**Example:**

```
Device# debug ip msdp resets
```

**Step 4** `show ip msdp count [as-number]`

Use this command to display the number of sources and groups originated in MSDP SA messages and the number of SA messages from an MSDP peer in the SA cache. The `ip msdp cache-sa-state` command must be configured for this command to produce any output.

The following is sample output from the `show ip msdp count` command:

**Example:**

```
Device# show ip msdp count
SA State per Peer Counters, <Peer>: <# SA learned>
 192.168.4.4: 8
SA State per ASN Counters, <asn>: <# sources>/<# groups>
Total entries: 8
?: 8/8
```

**Step 5** `show ip msdp peer` [*peer-address* | *peer-name*]

Use this command to display detailed information about MSDP peers.

Use the optional *peer-address* or *peer-name* argument to display information about a particular peer.

The following is sample output from the `show ip msdp peer` command:

**Example:**

```
Device# show ip msdp peer 192.168.4.4
MSDP Peer 192.168.4.4 (?), AS 64512 (configured AS)
Connection status:
  State: Up, Resets: 0, Connection source: Loopback0 (2.2.2.2)
  Uptime(Downtime): 00:07:55, Messages sent/received: 8/18
  Output messages discarded: 0
  Connection and counters cleared 00:08:55 ago
SA Filtering:
  Input (S,G) filter: none, route-map: none
  Input RP filter: none, route-map: none
  Output (S,G) filter: none, route-map: none
  Output RP filter: none, route-map: none
SA-Requests:
  Input filter: none
Peer ttl threshold: 0
SAs learned from this peer: 8
Input queue size: 0, Output queue size: 0
MD5 signature protection on MSDP TCP connection: not enabled
```

**Step 6** `show ip msdp sa-cache` [*group-address* | *source-address* | *group-name* | *source-name*] [*as-number*]

Use this command to display the (S, G) state learned from MSDP peers.

The following is sample output from the `show ip msdp sa-cache` command:

**Example:**

```
Device# show ip msdp sa-cache
MSDP Source-Active Cache - 8 entries
(10.44.44.5, 239.232.1.0), RP 192.168.4.4, BGP/AS 64512, 00:01:20/00:05:32, Peer 192.168.4.4
(10.44.44.5, 239.232.1.1), RP 192.168.4.4, BGP/AS 64512, 00:01:20/00:05:32, Peer 192.168.4.4
(10.44.44.5, 239.232.1.2), RP 192.168.4.4, BGP/AS 64512, 00:01:19/00:05:32, Peer 192.168.4.4
(10.44.44.5, 239.232.1.3), RP 192.168.4.4, BGP/AS 64512, 00:01:19/00:05:32, Peer 192.168.4.4
(10.44.44.5, 239.232.1.4), RP 192.168.4.4, BGP/AS 64512, 00:01:19/00:05:32, Peer 192.168.4.4
(10.44.44.5, 239.232.1.5), RP 192.168.4.4, BGP/AS 64512, 00:01:19/00:05:32, Peer 192.168.4.4
(10.44.44.5, 239.232.1.6), RP 192.168.4.4, BGP/AS 64512, 00:01:19/00:05:32, Peer 192.168.4.4
(10.44.44.5, 239.232.1.7), RP 192.168.4.4, BGP/AS 64512, 00:01:19/00:05:32, Peer 192.168.4.4
```

**Step 7** `show ip msdp summary`

Use this command to display MSDP peer status.

The following is sample output from the `show ip msdp summary` command:

**Example:**

```
Device# show ip msdp summary
MSDP Peer Status Summary
Peer Address      AS      State      Uptime/  Reset SA      Peer Name
```



			Downtime	Count	Count
192.168.4.4	4	Up	00:08:05	0	8 ?

## Clearing MSDP Connections Statistics and SA Cache Entries

Perform this optional task to clear MSDP connections, statistics, and SA cache entries.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>clear ip msdp peer</b> [ <i>peer-address</i>   <i>peer-name</i> ] <b>Example:</b> Device# <b>clear ip msdp peer</b>	Clears the TCP connection to the specified MSDP peer and resets all MSDP message counters.
<b>Step 3</b>	<b>clear ip msdp statistics</b> [ <i>peer-address</i>   <i>peer-name</i> ] <b>Example:</b> Device# clear ip msdp statistics	Clears the statistics counters for the specified MSDP peer and resets all MSDP message counters.
<b>Step 4</b>	<b>clear ip msdp sa-cache</b> [ <i>group-address</i> ] <b>Example:</b> Device# clear ip msdp sa-cache	Clears SA cache entries. <ul style="list-style-type: none"> <li>• If the <b>clear ip msdp sa-cache</b> is specified with the optional <i>group-address</i> argument or <i>source-address</i> argument, all SA cache entries are cleared.</li> <li>• Use the optional <i>group-address</i> argument to clear all SA cache entries associated with a specific group.</li> </ul>

## Enabling SNMP Monitoring of MSDP

Perform this optional task to enable Simple Network Management Protocol (SNMP) monitoring of MSDP.

### Before you begin

- SNMP and MSDP is configured on your devices.
- In each PIM-SM domain there should be a device that is configured as the MSDP speaker. This device must have SNMP and the MSDP MIB enabled.

**Note**

- All MSDP-MIB objects are implemented as read-only.
- The Requests table is not supported in Cisco's implementation of the MSDP MIB.
- The msdpEstablished notification is not supported in Cisco's implementation of the MSDP MIB.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>snmp-server enable traps msdp</b> <b>Example:</b> Device# snmp-server enable traps msdp	Enables the sending of MSDP notifications for use with SNMP. <b>Note</b> The <b>snmp-server enable traps msdp</b> command enables both traps and informs.
<b>Step 3</b>	<b>snmp-server host</b> <i>host</i> [ <b>traps</b>   <b>informs</b> ] [ <b>version</b> { <b>1</b>   <b>2c</b>   <b>3</b> [ <b>auth</b>   <b>priv</b>   <b>noauth</b> ]}] <i>community-string</i> [ <b>udp-port</b> <i>port-number</i> ] <b>msdp</b> <b>Example:</b> Device# snmp-server host examplehost msdp	Specifies the recipient (host) for MSDP traps or informs.
<b>Step 4</b>	<b>exit</b> <b>Example:</b> Device(config)# exit	Exits global configuration mode and returns to privileged EXEC mode.

## Troubleshooting Tips

You can compare the results of MSDP MIB notifications to the output from the software by using the **show ip msdp summary** and **show ip msdp peer** commands on the appropriate device. You can also compare the results of these commands to the results from SNMP Get operations. You can verify SA cache table entries using the **show ip msdp sa-cache** command. Additional troubleshooting information, such as the local address of the connection, the local port, and the remote port, can be obtained using the output from the **debug ip msdp** command.

# Configuration Examples for Using MSDP to Interconnect Multiple PIM-SM Domains

## Example: Configuring an MSDP Peer

The following example shows how to establish MSDP peering connections between three MSDP peers:

### Device A

```
!  
interface Loopback 0  
 ip address 10.220.8.1 255.255.255.255  
!  
ip msdp peer 10.220.16.1 connect-source Loopback0  
ip msdp peer 10.220.32.1 connect-source Loopback0  
!
```

### Device B

```
!  
interface Loopback 0  
 ip address 10.220.16.1 255.255.255.255  
!  
ip msdp peer 10.220.8.1 connect connect-source Loopback0  
ip msdp peer 10.220.32.1 connect connect-source Loopback0  
!
```

### Device C

```
!  
interface Loopback 0  
 ip address 10.220.32.1 255.255.255.255  
!  
ip msdp peer 10.220.8.1 connect 10.220.8.1 connect-source Loopback0  
ip msdp peer 10.220.16.1 connect 10.220.16.1 connect-source Loopback0  
!
```

## Example: Configuring MSDP MD5 Password Authentication

The following example shows how to enable MD5 password authentication for TCP connections between two MSDP peers:

### Device A

```
!  
ip msdp peer 10.3.32.154  
ip msdp password peer 10.3.32.154 0 test  
!
```

**Device B**

```

!
ip msdp peer 10.3.32.153
ip msdp password peer 10.3.32.153 0 test
!

```

**Example: Configuring a Default MSDP Peer**

The figure illustrates a scenario where default MSDP peers might be used. In the figure, a customer that owns Device B is connected to the internet through two ISPs, one that owns Device A and the other that owns Device C. They are not running (M)BGP between them. In order for the customer to learn about sources in the ISP domain or in other domains, Device B identifies Device A as its default MSDP peer. Device B advertises SA messages to both Device A and Device C, but accepts SA messages either from Device A only or Device C only. If Device A is the first default peer in the configuration, it will be used if it is up and running. Only if Device A is not running will Device B accept SA messages from Device C.

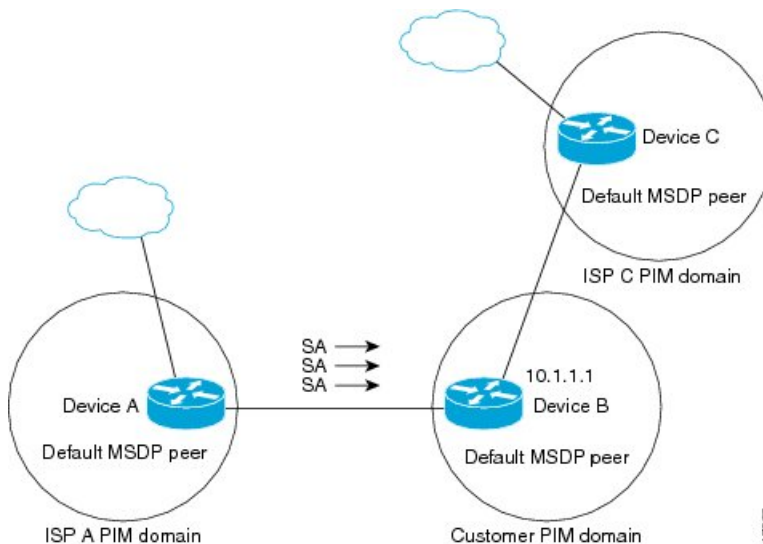
The ISP will also likely use a prefix list to define which prefixes it will accept from the customer device. The customer will define multiple default peers, each having one or more prefixes associated with it.

The customer has two ISPs to use. The customer defines both ISPs as default peers. As long as the first default peer identified in the configuration is up and running, it will be the default peer and the customer will accept all SA messages it receives from that peer.



**Note** Although the following illustration and example uses routers in the configuration, any device (router or switch) can be used.

**Figure 33: Default MSDP Peer Scenario**



Device B advertises SAs to Device A and Device C, but uses only Device A or Device C to accept SA messages. If Device A is first in the configuration file, it will be used if it is up and running. Only when Device A is not running will Device B accept SAs from Device C. This is the behavior without a prefix list.

If you specify a prefix list, the peer will be a default peer only for the prefixes in the list. You can have multiple active default peers when you have a prefix list associated with each. When you do not have any prefix lists, you can configure multiple default peers, but only the first one is the active default peer as long as the device has connectivity to this peer and the peer is alive. If the first configured peer goes down or the connectivity to this peer goes down, the second configured peer becomes the active default, and so on.

The following example shows a partial configuration of Device A and Device C in the figure. Each of these ISPs may have more than one customer using default peering, like the customer in the figure. In that case, they may have similar configurations. That is, they will only accept SAs from a default peer if the SA is permitted by the corresponding prefix list.

#### Device A Configuration

```
ip msdp default-peer 10.1.1.1
ip msdp default-peer 10.1.1.1 prefix-list site-b ge 32
ip prefix-list site-b permit 10.0.0.0/8
```

#### Device C Configuration

```
ip msdp default-peer 10.1.1.1 prefix-list site-b ge 32
ip prefix-list site-b permit 10.0.0.0/8
```

## Example: Configuring MSDP Mesh Groups

The following example shows how to configure three devices to be fully meshed members of an MSDP mesh group:

#### Device A Configuration

```
ip msdp peer 10.2.2.2
ip msdp peer 10.3.3.3
ip msdp mesh-group test-mesh-group 10.2.2.2
ip msdp mesh-group test-mesh-group 10.3.3.3
```

#### Device B Configuration

```
ip msdp peer 10.1.1.1
ip msdp peer 10.3.3.3
ip msdp mesh-group test-mesh-group 10.1.1.1
ip msdp mesh-group test-mesh-group 10.3.3.3
```

#### Device C Configuration

```
ip msdp peer 10.1.1.1
ip msdp peer 10.2.2.2
ip msdp mesh-group test-mesh-group 10.1.1.1
ip msdp mesh-group test-mesh-group 10.2.2.2
```

# Additional References

## Related Documents

Related Topic	Document Title
IPv6 addressing and connectivity	<i>IPv6 Configuration Guide</i>
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
IP multicast commands	<a href="#">Cisco IOS IP Multicast Command Reference</a>
IPv6 commands	<a href="#">Cisco IOS IPv6 Command Reference</a>
Cisco IOS IPv6 features	<a href="#">Cisco IOS IPv6 Feature Mapping</a>

## Standards and RFCs

Standard/RFC	Title
RFCs for IPv6	<i>IPv6 RFCs</i>

## MIBs

MIB	MIBs Link
	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

## Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

# Feature History and Information for Multicast Source Discovery Protocol

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.







## CHAPTER 34

# Configuring Wireless Multicast

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- [Prerequisites for Configuring Wireless Multicast, on page 619](#)
- [Restrictions on Configuring Wireless Multicast, on page 619](#)
- [Information About Wireless Multicast, on page 620](#)
- [How to Configure Wireless Multicast, on page 624](#)
- [Verifying Wireless Multicast, on page 631](#)
- [Where to Go Next for Wireless Multicast, on page 631](#)

## Prerequisites for Configuring Wireless Multicast

- IP multicast routing must be enabled and the PIM version and PIM mode must be configured. The default routes should be available in the device. After performing these tasks, the device can forward multicast packets and populate its multicast routing table.
- To participate in IP multicasting, the multicast hosts, routers, and multilayer switches must have IGMP operating.
- When enabling multicast mode on the device, a CAPWAP multicast group address should also be configured. Access points listen to the CAPWAP multicast group using IGMP.

## Restrictions on Configuring Wireless Multicast

The following are the restrictions for configuring IP multicast routing:

- Access points in monitor mode, sniffer mode, or rogue-detector mode do not join the CAPWAP multicast group address.
- The CAPWAP multicast group configured on the should be different for different devices.
- Multicast routing should not be enabled for the management interface.

## Restrictions for IPv6 Snooping

The IPv6 snooping feature is not supported on Etherchannel ports.

## Restrictions for IPv6 RA Guard

- The IPv6 RA Guard feature does not offer protection in environments where IPv6 traffic is tunneled.
- This feature is supported only in hardware when the ternary content addressable memory (TCAM) is programmed.
- This feature can be configured on a switch port interface in the ingress direction.
- This feature supports host mode and router mode.
- This feature is supported only in the ingress direction; it is not supported in the egress direction.
- This feature is not supported on EtherChannel and EtherChannel port members.
- This feature is not supported on trunk ports with merge mode.
- This feature is supported on auxiliary VLANs and private VLANs (PVLANS). In the case of PVLANS, primary VLAN features are inherited and merged with port features.
- Packets dropped by the IPv6 RA Guard feature can be spanned.
- If the **platform ipv6 acl icmp optimize neighbor-discovery command** is configured, the IPv6 RA Guard feature cannot be configured and an error message will be displayed. This command adds default global Internet Control Message Protocol (ICMP) entries that will override the RA guard ICMP entries.

## Information About Wireless Multicast

If the network supports packet multicasting, the multicast method that the device uses can be configured. The device performs multicasting in two modes:

- Unicast mode—The device unicasts every multicast packet to every access point associated to the device. This mode is inefficient, but is required on networks that do not support multicasting.
- Multicast mode—The device sends multicast packets to a CAPWAP multicast group. This method reduces the overhead on the device processor and shifts the work of packet replication to the network, which is much more efficient than the unicast method.

The flexconnect mode has two submodes: local switching and central switching. In local switching mode, the data traffic is switched at the AP level and the controller does not see any multicast traffic. In central switching mode, the multicast traffic reaches the controller. However, IGMP snooping takes place at the AP.

When the multicast mode is enabled and the device receives a multicast packet from the wired LAN, the device encapsulates the packet using CAPWAP and forwards the packet to the CAPWAP multicast group address. The device always uses the management VLAN for sending multicast packets. Access points in the multicast group receive the packet and forward it to all the BSSIDs mapped to the VLAN on which clients receive multicast traffic.

The device supports all the capabilities of IGMP v1, including Multicast Listener Discovery (MLD) v1 snooping, but the IGMP v2 and IGMP v3 capabilities are limited. This feature keeps track of and delivers IPv6 multicast flows to the clients that request them. To support IPv6 multicast, global multicast mode should be enabled.

Internet Group Management Protocol (IGMP) snooping is introduced to better direct multicast packets. When this feature is enabled, the device snooping gathers IGMP reports from the clients, processes them, creates

unique multicast group IDs (MGIDs) based on the Layer 3 multicast address and the VLAN number, and sends the IGMP reports to the IGMP querier. The device then updates the access-point MGID table on the corresponding access point with the client MAC address. When the device receives multicast traffic for a particular multicast group, it forwards it to all the access points, but only those access points that have active clients listening or subscribed to that multicast group send multicast traffic on that particular WLAN. IP packets are forwarded with an MGID that is unique for an ingress VLAN and the destination multicast group. Layer 2 multicast packets are forwarded with an MGID that is unique for the ingress VLAN.

MGID is a 14-bit value filled in the 16-bit reserved field of wireless information in the CAPWAP header. The remaining two bits should be set to zero.

## Multicast Optimization

Multicast used to be based on the group of the multicast addresses and the VLAN as one entity, MGID. With the VLAN group, duplicate packets might increase. Using the VLAN group feature, every client listens to the multicast stream on a different VLAN. As a result, the device creates different MGIDs for each multicast address and the VLAN. Therefore, the upstream router sends a copy for each VLAN, which results in as many copies as the number of VLANs in the group. Because the WLAN remains the same for all the clients, multiple copies of the multicast packet are sent over the wireless network. To suppress the duplication of a multicast stream on the wireless medium between the device and the access points, the multicast optimization feature can be used.

Multicast optimization enables you to create a multicast VLAN that can be used for multicast traffic. One of the VLANs in the device can be configured as a multicast VLAN where multicast groups are registered. The clients are allowed to listen to a multicast stream on the multicast VLAN. The MGID is generated using the multicast VLAN and multicast IP addresses. If multiple clients on different VLANs of the same WLAN are listening to a single multicast IP address, a single MGID is generated. The device makes sure that all the multicast streams from the clients on this VLAN group always go out on the multicast VLAN to ensure that the upstream router has one entry for all the VLANs of the VLAN group. Only one multicast stream hits the VLAN group even if the clients are on different VLANs. Therefore, the multicast packets that are sent out over the network is just one stream.

## IPv6 Global Policies

IPv6 global policies provide storage and access policy database services. IPv6 ND inspection and IPv6 RA guard are IPv6 global policies features. Every time an ND inspection or RA guard is configured globally, the policy attributes are stored in the software policy database. The policy is then applied to an interface, and the software policy database entry is updated to include this interface to which the policy is applied.

## IPv6 RA Guard

The IPv6 RA Guard feature provides support for allowing the network administrator to block or reject unwanted or rogue RA guard messages that arrive at the network device platform. RAs are used by devices to announce themselves on the link. The IPv6 RA Guard feature analyzes these RAs and filters out RAs that are sent by unauthorized devices. In host mode, all RA and router redirect messages are disallowed on the port. The RA guard feature compares configuration information on the Layer 2 (L2) device with the information found in the received RA frame. Once the L2 device has validated the content of the RA frame and router redirect frame against the configuration, it forwards the RA to its unicast or multicast destination. If the RA frame content is not validated, the RA is dropped.

In the wireless deployment RAs coming on wireless ports are dropped as routers cannot reside on these interfaces.

## Information About IPv6 Snooping

### IPv6 Neighbor Discovery Inspection

The IPv6 Neighbor Discovery Inspection, or IPv6 "snooping," feature bundles several Layer 2 IPv6 first-hop security features, including IPv6 Address Glean and IPv6 Device Tracking. IPv6 neighbor discovery (ND) inspection operates at Layer 2, or between Layer 2 and Layer 3, and provides IPv6 features with security and scalability. This feature mitigates some of the inherent vulnerabilities for the neighbor discovery mechanism, such as attacks on duplicate address detection (DAD), address resolution, device discovery, and the neighbor cache.

IPv6 ND inspection learns and secures bindings for stateless autoconfiguration addresses in Layer 2 neighbor tables and analyzes ND messages in order to build a trusted binding table. IPv6 ND messages that do not have valid bindings are dropped. An ND message is considered trustworthy if its IPv6-to-MAC mapping is verifiable. This feature mitigates some of the inherent vulnerabilities for the neighbor discovery mechanism, such as attacks on duplicate address detection (DAD), address resolution, device discovery, and the neighbor cache.

When IPv6 ND inspection is configured on a target (which varies depending on platform target support and may include device ports, switch ports, Layer 2 interfaces, Layer 3 interfaces, and VLANs), capture instructions are downloaded to the hardware to redirect the ND protocol and Dynamic Host Configuration Protocol (DHCP) for IPv6 traffic up to the switch integrated security features (SISF) infrastructure in the routing device. For ND traffic, messages such as NS, NA, RS, RA, and REDIRECT are directed to SISF. For DHCP, UDP messages sourced from port 546 or 547 are redirected.

IPv6 ND inspection registers its "capture rules" to the classifier, which aggregates all rules from all features on a given target and installs the corresponding ACL down into the platform-dependent modules. Upon receiving redirected traffic, the classifier calls all entry points from any registered feature (for the target on which the traffic is being received), including the IPv6 ND inspection entry point. This entry point is the last to be called, so any decision (such as drop) made by another feature supersedes the IPv6 ND inspection decision.

#### IPv6 ND Inspection

IPv6 ND inspection learns and secures bindings for stateless autoconfiguration addresses in Layer 2 neighbor tables. IPv6 ND inspection analyzes neighbor discovery messages in order to build a trusted binding table database, and IPv6 neighbor discovery messages that do not have valid bindings are dropped. A neighbor discovery message is considered trustworthy if its IPv6-to-MAC mapping is verifiable.

This feature mitigates some of the inherent vulnerabilities for the neighbor discovery mechanism, such as attacks on duplicate address detection (DAD), address resolution, device discovery, and the neighbor cache.

#### IPv6 Device Tracking

IPv6 device tracking provides IPv6 host liveness tracking so that a neighbor table can be immediately updated when an IPv6 host disappears.

#### *IPv6 First-Hop Security Binding Table*

The IPv6 First-Hop Security Binding Table recovery mechanism feature enables the binding table to recover in the event of a device reboot. A database table of IPv6 neighbors connected to the device is created from information sources such as ND snooping. This database, or binding, table is used by various IPv6 guard

features to validate the link-layer address (LLA), the IPv4 or IPv6 address, and prefix binding of the neighbors to prevent spoofing and redirect attacks.

This mechanism enables the binding table to recover in the event of a device reboot. The recovery mechanism will block any data traffic sourced from an unknown source; that is, a source not already specified in the binding table and previously learned through ND or DHCP gleaning. This feature recovers the missing binding table entries when the resolution for a destination address fails in the destination guard. When a failure occurs, a binding table entry is recovered by querying the DHCP server or the destination host, depending on the configuration.

## Recovery Protocols and Prefix Lists

The IPv6 First-Hop Security Binding Table Recovery Mechanism feature introduces the capability to provide a prefix list that is matched before the recovery is attempted for both DHCP and NDP.

If an address does not match the prefix list associated with the protocol, then the recovery of the binding table entry will not be attempted with that protocol. The prefix list should correspond to the prefixes that are valid for address assignment in the Layer 2 domain using the protocol. The default is that there is no prefix list, in which case the recovery is attempted for all addresses. The command to associate a prefix list to a protocol is **protocol {dhcp | ndp} [prefix-list *prefix-list-name*]**.

## IPv6 Device Tracking

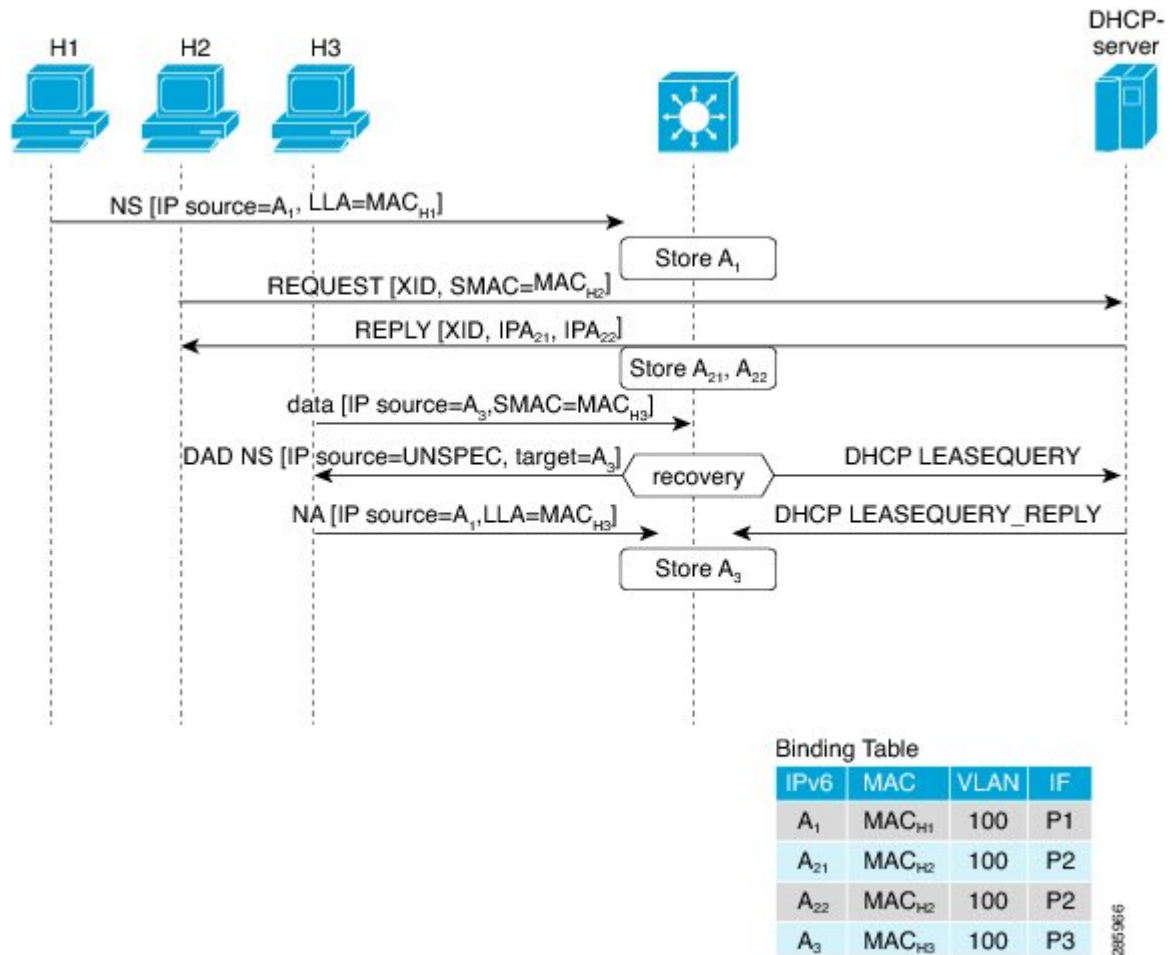
IPv6 device tracking provides IPv6 host liveness tracking so that a neighbor table can be immediately updated when an IPv6 host disappears.

## IPv6 Address Glean

IPv6 address glean is the foundation for many other IPv6 features that depend on an accurate binding table. It inspects ND and DHCP messages on a link to glean addresses, and then populates the binding table with these addresses. This feature also enforces address ownership and limits the number of addresses any given node is allowed to claim.

The following figure shows how IPv6 address glean works.

Figure 34: IPv6 Address Glean



# How to Configure Wireless Multicast

## Configuring Wireless Multicast-MCMC Mode (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password, if prompted.

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>wireless multicast</b> <b>Example:</b> Device(config)# <code>wireless multicast</code> Device(config)# <code>no wireless multicast</code>	Enables multicast traffic for wireless clients. By default, multicast traffic is in disabled state. Use the <b>no</b> form of this command to disable the multicast traffic for wireless clients.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Exits configuration mode. Alternatively, press <b>Ctrl-Z</b> to exit configuration mode.

## Configuring Wireless Multicast-MCUC Mode (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. Enter your password, if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>wireless multicast</b> <b>Example:</b> Device(config)# <code>wireless multicast</code>	Enables the multicast traffic for wireless clients and enables mDNS bridging. By default, the feature is in disabled state. Use the <b>no</b> form of this command to disable the multicast traffic for wireless clients and disable mDNS bridging.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Exits configuration mode. Alternatively, press <b>Ctrl-Z</b> to exit configuration mode.

## Configuring IPv6 Snooping (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password, if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 mld snooping</b> <b>Example:</b> Device(config)# <b>ipv6 mld snooping</b>	Enables MLD snooping.

## Configuring IPv6 Snooping Policy (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password, if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 snooping policy <i>policy-name</i></b> <b>Example:</b> Device(config)# <b>ipv6 snooping policy mypolicy</b>	Configures an IPv6 snooping policy with a name.
<b>Step 4</b>	<b>security-level guard</b> <b>Example:</b> Device(config-ipv6-snooping)# <b>security-level guard</b>	Configures the security level to inspect and drop unauthorized messages, if any.



	Command or Action	Purpose
<b>Step 5</b>	<b>device-role node</b> <b>Example:</b> Device(config-ipv6-snooping) # <b>device-role node</b>	Configures the role of the device, which is a node, to the attached port.
<b>Step 6</b>	<b>protocol {dhcp   ndp}</b> <b>Example:</b> Device(config-ipv6-snooping) # <b>protocol ndp</b>	Sets the protocol to glean addresses in either the DHCP or the NDP packets.

## Configuring Layer 2 Port as Multicast Router Port (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password, if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 mld snooping vlan <i>vlan-id</i> mrouter interface Port-channel <i>port-channel-interface-number</i></b> <b>Example:</b> Device(config)# <b>ipv6 mld snooping vlan 2 mrouter interface Port-channel 22</b>	Configures a Layer 2 port as a Multicast router port. The VLAN is the client VLAN.

## Configuring IPv6 RA Guard (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password, if prompted.

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 nd rguard policy <i>policy-name</i></b> <b>Example:</b> Device(config)# <code>ipv6 nd rguard policy myrguardpolicy</code>	Configures a policy for RA guard.
<b>Step 4</b>	<b>trusted-port</b> <b>Example:</b> Device(config-nd-rguard)# <code>trusted-port</code>	Sets up a trusted port.
<b>Step 5</b>	<b>device-role {host   monitor   router   switch}</b> <b>Example:</b> Device(config-nd-rguard)# <code>device-role router</code>	Sets the role of the device attached to the port.

## Configuring Non-IP Wireless Multicast (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. Enter your password, if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>wireless multicast non-ip</b> <b>Example:</b> Device(config)# <code>wireless multicast non-ip</code>  Device(config)# <code>no wireless multicast non-ip</code>	Enables non-IP multicast in all the VLANs. By default, the non-IP multicast in all the VLANs is in Disabled state. Wireless multicast must be enabled for the traffic to pass. Use the <b>no</b> form of this command to disable non-IP multicast in all the VLANs.
<b>Step 4</b>	<b>wireless multicast non-ip vlan <i>vlanid</i></b> <b>Example:</b> Device(config)# <code>wireless multicast non-ip vlan 5</code>	Enables non-IP multicast per VLAN. By default, non-IP multicast per VLAN is in Disabled state. Both wireless multicast and wireless multicast non-IP must be enabled for

	Command or Action	Purpose
	Device(config)# <b>no wireless multicast non-ip vlan 5</b>	traffic to pass. Use the <b>no</b> form of this command to disable non-IP multicast per VLAN.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Exits configuration mode. Alternatively, press <b>Ctrl-Z</b> to exit configuration mode.

## Configuring Wireless Broadcast (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password, if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>wireless broadcast</b> <b>Example:</b> Device(config)# <b>wireless broadcast</b> Device(config)# <b>no wireless broadcast</b>	Enables broadcast packets for wireless clients. By default, the broadcast packets for wireless clients is in Disabled state. Enabling <b>wireless broadcast</b> enables broadcast traffic for each VLAN. Use the <b>no</b> form of this command to disable broadcasting packets.
<b>Step 4</b>	<b>wireless broadcast vlan <i>vlanid</i></b> <b>Example:</b> Device(config)# <b>wireless broadcast vlan 3</b> Device(config)# <b>no wireless broadcast vlan 3</b>	Enables broadcast packets for single VLAN. By default, the Broadcast Packets for a Single VLAN feature is in Disabled state. Wireless broadcast must be enabled for broadcasting. Use the <b>no</b> form of this command to disable broadcast traffic for each VLAN.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Exits configuration mode. Alternatively, press <b>Ctrl-Z</b> to exit configuration mode.

## Configuring IP Multicast VLAN for WLAN (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password, if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>wlan wlan_name</b> <b>Example:</b> Device(config)# <b>wlan test 1</b>	Enters configuration mode to configure various parameters in the WLAN.
<b>Step 4</b>	<b>shutdown</b> <b>Example:</b> Device(config-wlan)# <b>shutdown</b>	Disables WLAN.
<b>Step 5</b>	<b>ip multicast vlan {vlan_name vlan_id}</b> <b>Example:</b> Device(config-wlan)# <b>ip multicast vlan 5</b> Device(config-wlan)# <b>no ip multicast vlan 5</b>	Configures multicast VLAN for WLAN. Use the <b>no</b> form of this command to disable the multicast VLAN for WLAN.
<b>Step 6</b>	<b>no shutdown</b> <b>Example:</b> Device(config-wlan)# <b>no shutdown</b>	Enables the disabled WLAN.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Exits configuration mode. Alternatively, press <b>Ctrl-Z</b> to exit configuration mode.

## Verifying Wireless Multicast

Table 46: Commands for Verifying Wireless Multicast

Command	Description
<b>show wireless multicast</b>	Displays the multicast status and IP multicast mode, and each VLAN's broadcast and non-IP multicast status. Also displays the Multicast Domain Name System (mDNS) bridging state.
<b>show wireless multicast group summary</b>	Displays all (Group and VLAN) lists and the corresponding MGID values.
<b>show wireless multicast [source <i>source</i>] group <i>group</i> vlan <i>vlanid</i></b>	Displays details of the specified (S,G,V) and shows all the clients associated with and their MC2UC status.
<b>show ip igmp snooping wireless mcast-spi-count</b>	Displays statistics of the number of multicast SPIs per MGID sent between IOS and the Wireless Controller Module.
<b>show ip igmp snooping wireless mgid</b>	Displays the MGID mappings.
<b>show ip igmp snooping igmpv2-tracking</b>	Displays the client-to-SGV mappings and the SGV-to-client mappings.
<b>show ip igmp snooping querier vlan <i>vlanid</i></b>	Displays the IGMP querier information for the specified VLAN.
<b>show ip igmp snooping querier detail</b>	Displays the detailed IGMP querier information of all the VLANs.
<b>show ipv6 mld snooping querier vlan <i>vlanid</i></b>	Displays the MLD querier information for the specified VLAN.
<b>show ipv6 mld snooping wireless mgid</b>	Displays MGIDs for the IPv6 multicast group.

## Where to Go Next for Wireless Multicast

You can configure the following:

- IGMP
- PIM
- SSM
- IP Multicast Routing
- Service Discovery Gateway





## CHAPTER 35

# Configuring SSM

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- [Prerequisites for Configuring SSM, on page 633](#)
- [Restrictions for Configuring SSM, on page 633](#)
- [Information About SSM, on page 635](#)
- [How to Configure SSM, on page 638](#)
- [Monitoring SSM, on page 644](#)
- [Where to Go Next for SSM, on page 645](#)
- [Additional References, on page 646](#)
- [Feature History and Information for SSM, on page 647](#)

## Prerequisites for Configuring SSM

The following are the prerequisites for configuring source-specific multicast (SSM) and SSM mapping:

- Before you configure SSM mapping, you must perform the following tasks:
  - Enable IP multicast routing.
  - Enable PIM sparse mode.
  - Configure SSM.
- Before you configure static SSM mapping, you must configure access control lists (ACLs) that define the group ranges to be mapped to source addresses.
- Before you can configure and use SSM mapping with DNS lookups, you need to add records to a running DNS server. If you do not already have a DNS server running, you need to install one.



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**Note** You can use a product such as *Cisco Network Registrar* to add records to a running DNS server.

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## Restrictions for Configuring SSM

The following are the restrictions for configuring SSM:

- To run SSM with IGMPv3, SSM must be supported in the Cisco IOS router, the host where the application is running, and the application itself.
- Existing applications in a network predating SSM will not work within the SSM range unless they are modified to support (S, G) channel subscriptions. Therefore, enabling SSM in a network may cause problems for existing applications if they use addresses within the designated SSM range.
- IGMP Snooping—IGMPv3 uses new membership report messages that might not be correctly recognized by older IGMP snooping devices.
- Address management is still necessary to some degree when SSM is used with Layer 2 switching mechanisms. Cisco Group Management Protocol (CGMP), IGMP snooping, or Router-Port Group Management Protocol (RGMP) support only group-specific filtering, not (S, G) channel-specific filtering. If different receivers in a switched network request different (S, G) channels sharing the same group, they do not benefit from these existing mechanisms. Instead, both receivers receive all (S, G) channel traffic and filter out the unwanted traffic on input. Because SSM can re-use the group addresses in the SSM range for many independent applications, this situation can lead to decreased traffic filtering in a switched network. For this reason, it is important to use random IP addresses from the SSM range for an application to minimize the chance for re-use of a single address within the SSM range between different applications. For example, an application service providing a set of television channels should, even with SSM, use a different group for each television (S, G) channel. This setup guarantees that multiple receivers to different channels within the same application service never experience traffic aliasing in networks that include Layer 2 devices.
- In PIM-SSM, the last hop router will continue to periodically send (S, G) join messages if appropriate (S, G) subscriptions are on the interfaces. Therefore, as long as receivers send (S, G) subscriptions, the shortest path tree (SPT) state from the receivers to the source will be maintained, even if the source is not sending traffic for longer periods of time (or even never).

The opposite situation occurs with PIM-SM, where (S, G) state is maintained only if the source is sending traffic and receivers are joining the group. If a source stops sending traffic for more than 3 minutes in PIM-SM, the (S, G) state is deleted and only reestablished after packets from the source arrive again through the RPT (rendezvous point tree). Because no mechanism in PIM-SSM notifies a receiver that a source is active, the network must maintain the (S, G) state in PIM-SSM as long as receivers are requesting receipt of that channel.

The following are the restrictions for configuring SSM mapping:

- The SSM Mapping feature does not share the benefit of full SSM. SSM mapping takes a group G join from a host and identifies this group with an application associated with one or more sources, therefore, it can only support one such application per group G. Nevertheless, full SSM applications may still share the same group also used in SSM mapping.
- Enable IGMPv3 with care on the last hop router when you rely solely on SSM mapping as a transition solution for full SSM. When you enable both SSM mapping and IGMPv3 and the hosts already support IGMPv3 (but not SSM), the hosts send IGMPv3 group reports. SSM mapping does not support these IGMPv3 group reports, and the router does not correctly associate sources with these reports.



## Information About SSM

The source-specific multicast (SSM) feature is an extension of IP multicast in which datagram traffic is forwarded to receivers from only those multicast sources that the receivers have explicitly joined. For multicast groups configured for SSM, only SSM distribution trees (no shared trees) are created.

This section describes how to configure source-specific multicast (SSM). For a complete description of the SSM commands in this section, refer to the *IP Multicast Command Reference*. To locate documentation for other commands that appear in this chapter, use the command reference master index, or search online.

## SSM Components Overview

SSM is a datagram delivery model that best supports one-to-many applications, also known as broadcast applications. SSM is a core networking technology for the Cisco implementation of IP multicast solutions targeted for audio and video broadcast application environments. The device supports the following components that support SSM implementation:

- Protocol independent multicast source-specific mode (PIM-SSM)  
PIM-SSM is the routing protocol that supports the implementation of SSM and is derived from PIM sparse mode (PIM-SM).
- Internet Group Management Protocol version 3 (IGMPv3)

## SSM and Internet Standard Multicast (ISM)

The current IP multicast infrastructure in the Internet and many enterprise intranets is based on the PIM-SM protocol and Multicast Source Discovery Protocol (MSDP). These protocols have the limitations of the Internet Standard Multicast (ISM) service model. For example, with ISM, the network must maintain knowledge about which hosts in the network are actively sending multicast traffic.

The ISM service consists of the delivery of IP datagrams from any source to a group of receivers called the multicast host group. The datagram traffic for the multicast host group consists of datagrams with an arbitrary IP unicast source address (S) and the multicast group address (G) as the IP destination address. Systems receive this traffic by becoming members of the host group. Membership in a host group simply requires signaling the host group through IGMP version 1, 2, or 3.

In SSM, delivery of datagrams is based on (S, G) channels. In both SSM and ISM, no signaling is required to become a source. However, in SSM, receivers must subscribe or unsubscribe to (S, G) channels to receive or not receive traffic from specific sources. In other words, receivers can receive traffic only from (S, G) channels to which they are subscribed, whereas in ISM, receivers need not know the IP addresses of sources from which they receive their traffic. The proposed standard approach for channel subscription signaling uses IGMP and includes modes membership reports, which are supported only in IGMP version 3.

## SSM IP Address Range

SSM can coexist with the ISM service by applying the SSM delivery model to a configured subset of the IP multicast group address range. Cisco IOS software allows SSM configuration for the IP multicast address range of 224.0.0.0 through 239.255.255.255. When an SSM range is defined, existing IP multicast receiver

applications do not receive any traffic when they try to use an address in the SSM range (unless the application is modified to use an explicit (S, G) channel subscription).

## SSM Operations

An established network, in which IP multicast service is based on PIM-SM, can support SSM services. SSM can also be deployed alone in a network without the full range of protocols required for interdomain PIM-SM (for example, MSDP, Auto-RP, or bootstrap router [BSR]) if only SSM service is needed.

If SSM is deployed in a network already configured for PIM-SM, only the last-hop routers support SSM. Routers that are not directly connected to receivers do not require support for SSM. In general, these not-last-hop routers must only run PIM-SM in the SSM range and might need additional access control configuration to suppress MSDP signalling, registering, or PIM-SM shared tree operations from occurring within the SSM range.

Use the **ip pim ssm** global configuration command to configure the SSM range and to enable SSM. This configuration has the following effects:

- For groups within the SSM range, (S, G) channel subscriptions are accepted through IGMPv3 include-mode membership reports.
- PIM operations within the SSM range of addresses change to PIM-SSM, a mode derived from PIM-SM. In this mode, only PIM (S, G) join and prune messages are generated by the router, and no (S, G) rendezvous point tree (RPT) or (\*, G) RPT messages are generated. Incoming messages related to RPT operations are ignored or rejected, and incoming PIM register messages are immediately answered with register-stop messages. PIM-SSM is backward-compatible with PIM-SM unless a router is a last-hop router. Therefore, routers that are not last-hop routers can run PIM-SM for SSM groups (for example, if they do not yet support SSM).
- No MSDP source-active (SA) messages within the SSM range are accepted, generated, or forwarded.

## SSM Mapping

In a typical set-top box (STB) deployment, each TV channel uses one separate IP multicast group and has one active server host sending the TV channel. A single server can send multiple TV channels, but each to a different group. In this network environment, if a router receives an IGMPv1 or IGMPv2 membership report for a particular group, the report addresses the well-known TV server for the TV channel associated with the multicast group.

When SSM mapping is configured, if a router receives an IGMPv1 or IGMPv2 membership report for a particular group, the router translates this report into one or more channel memberships for the well-known sources associated with this group.

When the router receives an IGMPv1 or IGMPv2 membership report for a group, the router uses SSM mapping to determine one or more source IP addresses for the group. SSM mapping then translates the membership report as an IGMPv3 report and continues as if it had received an IGMPv3 report. The router then sends PIM joins and continues to be joined to these groups as long as it continues to receive the IGMPv1 or IGMPv2 membership reports, and the SSM mapping for the group remains the same.

SSM mapping enables the last hop router to determine the source addresses either by a statically configured table on the router or through a DNS server. When the statically configured table or the DNS mapping changes, the router leaves the current sources associated with the joined groups.

## Static SSM Mapping

With static SSM mapping, you can configure the last hop router to use a static map to determine the sources that are sending to groups. Static SSM mapping requires that you configure ACLs to define group ranges. After configuring the ACLs to define group ranges, you can then map the groups permitted by those ACLs to sources by using the **ip igmp ssm-map static** global configuration command.

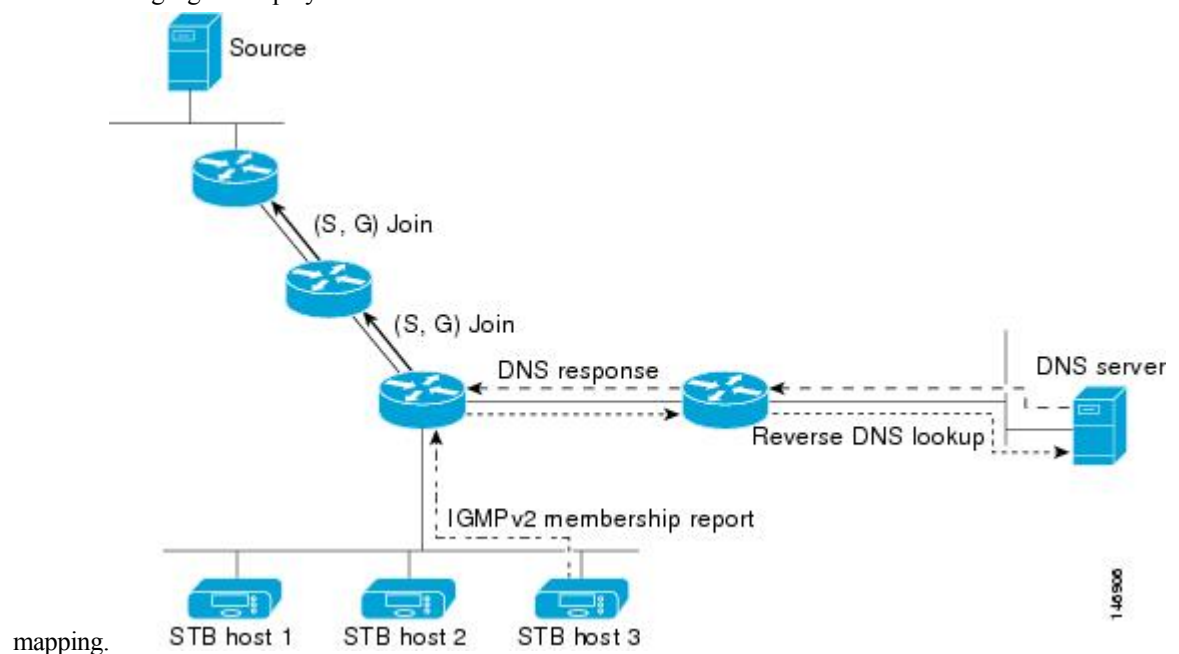
You can configure static SSM mapping in smaller networks when a DNS is not needed or to locally override DNS mappings. When configured, static SSM mappings take precedence over DNS mappings.

## DNS-Based SSM Mapping

You can use DNS-based SSM mapping to configure the last hop router to perform a reverse DNS lookup to determine sources sending to groups. When DNS-based SSM mapping is configured, the router constructs a domain name that includes the group address and performs a reverse lookup into the DNS. The router looks up IP address resource records and uses them as the source addresses associated with this group. SSM mapping supports up to 20 sources for each group. The router joins all sources configured for a group.

**Figure 35: DNS-Based SSM Mapping**

The following figure displays DNS-based SSM



The SSM mapping mechanism that enables the last hop router to join multiple sources for a group can provide source redundancy for a TV broadcast. In this context, the last hop router provides redundancy using SSM mapping to simultaneously join two video sources for the same TV channel. However, to prevent the last hop router from duplicating the video traffic, the video sources must use a server-side switchover mechanism. One video source is active, and the other backup video source is passive. The passive source waits until an active source failure is detected before sending the video traffic for the TV channel. Thus, the server-side switchover mechanism ensures that only one of the servers is actively sending video traffic for the TV channel.

To look up one or more source addresses for a group that includes G1, G2, G3, and G4, you must configure these DNS records on the DNS server:

```
G4.G3.G2.G1 [multicast-domain] [timeout] IN A source-address-1
```

```
IN A source-address-2
IN A source-address-n
```

See your DNS server documentation for more information about configuring DNS resource records.

## How to Configure SSM

For a complete description of the source-specific multicast (SSM) commands in this section, see the *IP Multicast Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)*. To locate documentation for other commands that appear in this chapter, use the command reference master index, or search online.

### Configuring SSM (CLI)

Follow these steps to configure SSM:

This procedure is optional.

#### Before you begin

If you want to use an access list to define the Source Specific Multicast (SSM) range, configure the access list before you reference the access list in the **ip pim ssm** command.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip pim ssm [default   range <i>access-list</i>]</b> <b>Example:</b> Device(config)# <b>ip pim ssm range 20</b>	Defines the SSM range of IP multicast addresses.
<b>Step 4</b>	<b>interface <i>type number</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet</b>	Selects an interface that is connected to hosts on which IGMPv3 can be enabled, and enters the interface configuration mode.  The specified interface must be one of the following:

	Command or Action	Purpose
	1/0/1	<ul style="list-style-type: none"> <li>• A routed port—A physical port that has been configured as a Layer 3 port by entering the <b>no switchport</b> interface configuration command.</li> <li>• An SVI—A VLAN interface created by using the <b>interface vlan</b> <i>vlan-id</i> global configuration command.</li> </ul> <p>These interfaces must have IP addresses assigned to them.</p>
<b>Step 5</b>	<b>ip pim {sparse-mode   }</b> <b>Example:</b> <pre>Device(config-if)# ip pim sparse-mode</pre>	Enables PIM on an interface.
<b>Step 6</b>	<b>ip igmp version 3</b> <b>Example:</b> <pre>Device(config-if)# ip igmp version 3</pre>	Enables IGMPv3 on this interface. The default version of IGMP is set to Version 2.
<b>Step 7</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring Source Specific Multicast Mapping

The Source Specific Multicast (SSM) mapping feature supports SSM transition when supporting SSM on the end system is impossible or unwanted due to administrative or technical reasons. You can use SSM mapping to leverage SSM for video delivery to legacy STBs that do not support IGMPv3 or for applications that do not use the IGMPv3 host stack.

## Configuring Static SSM Mapping (CLI)

Follow these steps to configure static SSM Mapping:

For additional information on SSM mapping, see the IP Multicast CG Library, Cisco IOS XE Release 3SE (Catalyst 3850 Switches).

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip igmp ssm-map enable</b> <b>Example:</b> Device(config)# <b>ip igmp ssm-map enable</b>	Enables SSM mapping for groups in the configured SSM range. <b>Note</b> By default, this command enables DNS-based SSM mapping.
<b>Step 4</b>	<b>no ip igmp ssm-map query dns</b> <b>Example:</b> Device(config)# <b>no ip igmp ssm-map query dns</b>	(Optional) Disables DNS-based SSM mapping. <b>Note</b> Disable DNS-based SSM mapping if you only want to rely on static SSM mapping. By default, the <b>ip igmp ssm-map</b> command enables DNS-based SSM mapping.
<b>Step 5</b>	<b>ip igmp ssm-map static <i>access-list source-address</i></b> <b>Example:</b> Device(config)# <b>ip igmp ssm-map static 11 172.16.8.11</b>	Configures static SSM mapping. <ul style="list-style-type: none"> <li>• The ACL supplied for the <i>access-list</i> argument defines the groups to be mapped to the source IP address entered for the <i>source-address</i> argument.</li> </ul>

	Command or Action	Purpose
		<p><b>Note</b> You can configure additional static SSM mappings. If additional SSM mappings are configured and the router receives an IGMPv1 or IGMPv2 membership report for a group in the SSM range, the device determines the source addresses associated with the group by walking each configured <b>ip igmp ssm-map static</b> command. The device associates up to 20 sources per group.</p> <p>Repeat Step to configure additional static SSM mappings, if required.</p>
<b>Step 6</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 7</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 8</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring DNS-Based SSM Mapping (CLI)

To configure DNS-based SSM mapping, you need to create a DNS server zone or add records to an existing zone. If the routers that are using DNS-based SSM mapping are also using DNS for other purposes, you should use a normally configured DNS server. If DNS-based SSM mapping is the only DNS implementation being used on the router, you can configure a false DNS setup with an empty root zone or a root zone that points back to itself.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
	Device> <b>enable</b>	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip igmp ssm-map enable</b> <b>Example:</b> Device(config)# ip igmp ssm-map enable	Enables SSM mapping for groups in a configured SSM range.
<b>Step 4</b>	<b>ip igmp ssm-map query dns</b> <b>Example:</b> Device(config)# ip igmp ssm-map query dns	(Optional) Enables DNS-based SSM mapping.  <ul style="list-style-type: none"> <li>By default, the <b>ip igmp ssm-map</b> command enables DNS-based SSM mapping. Only the <b>no</b> form of this command is saved to the running configuration.</li> </ul> <p><b>Note</b> Use this command to reenables DNS-based SSM mapping if DNS-based SSM mapping is disabled.</p>
<b>Step 5</b>	<b>ip domain multicast</b> <i>domain-prefix</i> <b>Example:</b> Device(config)# ip domain multicast ssm-map.cisco.com	(Optional) Changes the domain prefix used for DNS-based SSM mapping.  <ul style="list-style-type: none"> <li>By default, the software uses the ip-addr.arpa domain prefix.</li> </ul>
<b>Step 6</b>	<b>ip name-server</b> <i>server-address1</i> [ <i>server-address2...server-address6</i> ] <b>Example:</b> Device(config)# ip name-server 10.48.81.21	Specifies the address of one or more name servers to use for name and address resolution.
<b>Step 7</b>	Repeat Step 6 to configure additional DNS servers for redundancy, if required.	
<b>Step 8</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.



	Command or Action	Purpose
<b>Step 9</b>	<b>show running-config</b> <b>Example:</b> Device# <code>show running-config</code>	Verifies your entries.
<b>Step 10</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring Static Traffic Forwarding with SSM Mapping (CLI)

Follow these steps to configure static traffic forwarding with SSM mapping on the last hop router:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <code>interface gigabitethernet 1/0/1</code>	Selects an interface on which to statically forward traffic for a multicast group using SSM mapping, and enters interface configuration mode.  The specified interface must be one of the following: <ul style="list-style-type: none"> <li>• A routed port—A physical port that has been configured as a Layer 3 port by entering the <b>no switchport</b> interface configuration command.</li> <li>• An SVI—A VLAN interface created by using the <b>interface vlan <i>vlan-id</i></b> global configuration command.</li> </ul>

	Command or Action	Purpose
		<p>These interfaces must have IP addresses assigned to them.</p> <p><b>Note</b> Static forwarding of traffic with SSM mapping works with either DNS-based SSM mapping or statically configured SSM mapping.</p>
<b>Step 4</b>	<p><b>ip igmp static-group <i>group-address</i> source ssm-map</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# ip igmp static-group 239.1.2.1 source ssm-map</pre>	<p>Configures SSM mapping to statically forward a (S, G) channel from the interface.</p> <p>Use this command if you want to statically forward SSM traffic for certain groups. Use DNS-based SSM mapping to determine the source addresses of the channels.</p>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	<p>Returns to privileged EXEC mode.</p>
<b>Step 6</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	<p>Verifies your entries.</p>
<b>Step 7</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	<p>(Optional) Saves your entries in the configuration file.</p>

## Monitoring SSM

Use the privileged EXEC commands in the following table to monitor SSM.

**Table 47: Commands for Monitoring SSM**

Command	Purpose
<b>show ip igmp groups detail</b>	Displays the (S, G) channel subscription through IGMPv3.

Command	Purpose
<code>show ip mroute</code>	Displays whether a multicast group supports SSM service or whether a source-specific host report was received.

## Monitoring SSM Mapping

Use the privileged EXEC commands in the following table to monitor SSM mapping.

**Table 48: SSM Mapping Monitoring Commands**

Command	Purpose
Device# <code>show ip igmp ssm-mapping</code>	Displays information about SSM mapping.
Device# <code>show ip igmp ssm-mapping group-address</code>	Displays the sources that SSM mapping uses for a particular group.
Device# <code>show ip igmp groups</code> [ <i>group-name</i>   <i>group-address</i>   <i>interface-type interface-number</i> ] [ <b>detail</b> ]	Displays the multicast groups with receivers that are directly connected to the router and that were learned through IGMP.
Device# <code>show host</code>	Displays the default domain name, the style of name lookup service, a list of name server hosts, and the cached list of hostnames and addresses.
Device# <code>debug ip igmp group-address</code>	Displays the IGMP packets received and sent and IGMP host-related events.

## Where to Go Next for SSM

You can configure the following:

- IGMP
- PIM
- IP Multicast Routing
- Service Discovery Gateway

# Additional References

## Related Documents

Related Topic	Document Title
SSM and other available commands	<i>IP Multicast Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>
Platform-independent configuration information	<ul style="list-style-type: none"> <li>• <i>IP Multicast: PIM Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i></li> <li>• <i>IP Multicast: IGMP Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i></li> <li>• <i>IP Multicast: Multicast Optimization Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i></li> </ul>

## Standards and RFCs

Standard/RFC	Title
RFC 4601	<i>Protocol-Independent Multicast-Sparse Mode (PIM-SM): Protocol Specification</i>

## MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

## Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for SSM

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.





## CHAPTER 36

# Configuring Multicast Routing over GRE Tunnel

- [Prerequisites for Configuring Multicast Routing over GRE Tunnel, on page 649](#)
- [Restrictions for Configuring Multicast Routing over GRE Tunnel, on page 649](#)
- [Information About Multicast Routing over GRE Tunnel, on page 649](#)
- [How to Configure Multicast Routing over GRE Tunnel, on page 650](#)

## Prerequisites for Configuring Multicast Routing over GRE Tunnel

Before configuring multicast routing over GRE, you should be familiar with the concepts of IP Multicast Routing Technology and GRE Tunneling.

## Restrictions for Configuring Multicast Routing over GRE Tunnel

The following are the restrictions for configuring multicast routing over GRE tunnel:

- IPv6 multicast over GRE tunnel is not supported.
- The total number of supported multicast routes (mroutes) is 32000, across all tunnels.  
Use the formula  $8000 / (((\text{Number of tunnels}) / 4) + 1)$  to derive the number of mroutes.
- Bidirectional PIM is not supported.
- Multicast routing should be configured on the first hop router (FHR), the rendezvous point (RP) and the last hop router (LHR) to support multicast over the GRE tunnel.
- On Catalyst 3850 series switches, the tunnel source can be a loopback, physical, or L3 EtherChannel interface.
- No feature interactions such as IPSec, ACL, Tunnel counters, Crypto support, Fragmentation, Cisco Discovery Protocol (CDP), QoS, GRE keepalive, Multipoint GRE, etc. are supported on the GRE Tunnel.

## Information About Multicast Routing over GRE Tunnel

This chapter describes how to configure a Generic Route Encapsulation (GRE) tunnel to tunnel IP multicast packets between non-IP multicast areas. The benefit is that IP multicast traffic can be sent from a source to a

multicast group, over an area where IP multicast is not supported. Multicast Routing over GRE Tunnel supports sparse mode and pim-ssm mode; and supports static RP and auto-RP. See Rendezvous Point and Auto-RP for information on configuring static RP and auto-RP.



**Note** Beginning in Cisco IOS XE Denali 16.3.1, multicast routing and NHRP are supported with GRE Tunneling. NHRP can optionally be configured along with the multicast configuration on the tunnel interface to facilitate dynamic discovery of tunnel end points. Please see NHRP for configuring NHRP on a tunnel interface.

#### Benefits of Tunneling to Connect Non-IP Multicast Areas

- If the path between a source and a group member (destination) does not support IP multicast, a tunnel between them can transport IP multicast packets.

## How to Configure Multicast Routing over GRE Tunnel

### Configuring a GRE Tunnel to Connect Non-IP Multicast Areas

You can configure a GRE tunnel to transport IP multicast packets between a source and destination that are connected by a medium that does not support multicast routing.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip multicast-routing</b> <b>Example:</b>  Device(config)# ip multicast-routing	Enables IP multicast routing.
<b>Step 4</b>	<b>interface tunnel <i>number</i></b> <b>Example:</b>  Device(config)# interface tunnel 0	Enters tunnel interface configuration mode.

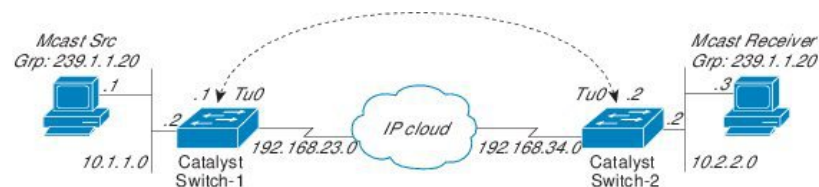


	Command or Action	Purpose
<b>Step 5</b>	<b>ip address ip_address subnet_mask</b> <b>Example:</b>  Device(config-if)# ip address 192.168.24.1 255.255.255.252	Configures IP address and IP subnet.
<b>Step 6</b>	<b>ip pim sparse-mode</b> <b>Example:</b>  Device(config-if)# ip pim sparse-mode	Enables sparse mode of operation of Protocol Independent Multicast (PIM) on the tunnel interface with one of the following mode of operation:
<b>Step 7</b>	<b>tunnel source { ip-address   interface-name }</b> <b>Example:</b>  Device(config-if)# tunnel source 100.1.1.1	Configures the tunnel source.
<b>Step 8</b>	<b>tunnel destination { hostname   ip-address }</b> <b>Example:</b>  Device(config-if)# tunnel destination 100.1.1.3	Configures the tunnel destination.
<b>Step 9</b>	<b>end</b> <b>Example:</b>  Device(config-if)# end	Ends the current configuration session and returns to privileged EXEC mode.
<b>Step 10</b>	<b>show interface type number</b> <b>Example:</b>  Device# show interface tunnel 0	Displays tunnel interface information.

## Tunneling to Connect Non-IP Multicast Areas Example

The following example shows multicast-routing between a Catalyst 3650/3850 switch through a GRE tunnel.

**Figure 36: Tunnel Connecting Non-IP Multicast Areas**



In the figure above, the multicast source (10.1.1.1) is connected to Catalyst 3650/3850 Switch-1 and is configured for multicast group 239.1.1.20. The multicast receiver (10.2.2.3) is connected to Catalyst 3650/3850 Switch-2 and is configured to receive multicast packets for group 239.1.1.20. Separating Switch-1 and Switch-2 is an IP cloud, which is not configured for multicast routing.

A GRE tunnel is configured between Switch-1 to Switch-2 sourced with their loopback interfaces. Multicast-routing is enabled on Switch-1 and Switch-2. The **ip pim sparse-mode** command is configured on tunnel interfaces to support PIM in the sparse mode. Sparse mode configuration on the tunnel interfaces allows sparse-mode packets to be forwarded over the tunnel depending on rendezvous point (RP) configuration for the group.

### Switch-1 Configuration:

```
Device(config)# ip multicast-routing
Device(config)# interface Loopback0 //Tunnel source interface
Device(config-if)# ip address 2.2.2.2 255.255.255.255

Device(config)# interface Tunnel 10 //Tunnel interface configured for PIM
traffic
Device(config-if)# ip address 192.168.24.1 255.255.255.252
Device(config-if)# ip pim sparse-mode
Device(config-if)# ip nhrp map 192.168.24.3 4.4.4.4 //NHRP may optionally be
configured to dynamically discover tunnel end points.
Device(config-if)# ip nhrp map multicast 4.4.4.4
Device(config-if)# ip nhrp network-id 1
Device(config-if)# ip nhrp nhs 192.168.24.3
Device(config-if)# tunnel source Loopback0
Device(config-if)# tunnel destination 4.4.4.4

Device(config)# interface GigabitEthernet 0/0/0 //Source interface
Device(config-if)# ip address 10.1.1.2 255.255.255.0
Device(config-if)# ip pim sparse-mode
```

### Switch-2 Configuration:

```
Device(config)# ip multicast-routing
Device(config)# interface Loopback0 //Tunnel source interface
Device(config-if)# ip address 4.4.4.4 255.255.255.255

Device(config)# interface Tunnel 10 //Tunnel interface configured for PIM
traffic
Device(config-if)# ip address 192.168.24.2 255.255.255.252
Device(config-if)# ip nhrp map 192.168.24.4 2.2.2.2 //NHRP may optionally be
configured to dynamically discover tunnel end points.
Device(config-if)# ip nhrp map multicast 2.2.2.2
Device(config-if)# ip nhrp network-id 1
Device(config-if)# ip nhrp nhs 192.168.24.4
Device(config-if)# ip pim sparse-mode
Device(config-if)# tunnel source Loopback0
Device(config-if)# tunnel destination 2.2.2.2

Device(config)# interface GigabitEthernet 0/0/0 //Receiver interface
Device(config-if)# ip address 10.2.2.2 255.255.255.0
Device(config-if)# ip pim sparse-mode
```



## CHAPTER 37

# Configuring the Service Discovery Gateway

- [Restrictions for Configuring the Service Discovery Gateway, on page 653](#)
- [Information about the Service Discovery Gateway and mDNS, on page 653](#)
- [How to Configure the Service Discovery Gateway, on page 656](#)
- [Monitoring Service Discovery Gateway, on page 661](#)
- [Configuration Examples, on page 661](#)
- [Where to Go Next for Configuring Services Discovery Gateway, on page 663](#)
- [Additional References, on page 663](#)
- [Feature History and Information for Services Discovery Gateway, on page 664](#)

## Restrictions for Configuring the Service Discovery Gateway

The following are restrictions for configuring the Service Discovery Gateway:

- The Service Discovery Gateway does not support topologies with multiple hops. All network segments must be connected directly to it. The Service Discovery Gateway can learn services from all connected segments to build its cache and respond to requests acting as a proxy.
- The use of third-party mDNS servers or applications are not supported with this feature.
- On a Cat4500sup8e MC (3.7 ) running mDNS, iphone and ipads running iOS7.0 might have problems in accessing print services through mDNS.

## Information about the Service Discovery Gateway and mDNS

### mDNS

mDNS was defined to achieve zero configuration, with zero configuration being defined as providing the following features:

- Addressing—Allocating IP addresses to hosts
- Naming—Using names to refer to hosts instead of IP addresses
- Service discovery—Finding services automatically on the network

With mDNS, network users no longer have to assign IP addresses, assign host names, or type in names to access services on the network. Users only need to ask to see what network services are available, and choose from a list.

With mDNS, *addressing* is accomplished through the use of DHCP/DHCPv6 or IPv4 and IPv6 Link Local scoped addresses. The benefit of zero-configuration occurs when no infrastructure services such as DHCP or DNS are present and self-assigned link-local addressing can be used. The client can then select a random IPv4 address in the link-local range (169.254.0.0/24) or use its IPv6 link-local address (FE80::/10) for communication.

With mDNS, *naming* (name-to-address translation on a local network using mDNS) queries are sent over the local network using link-local scoped IP multicast. Because these DNS queries are sent to a multicast address (IPv4 address 224.0.0.251 or IPv6 address FF02::FB), no single DNS server with global knowledge is required to answer the queries. When a service or device sees a query for any service it is aware of, it provides a DNS response with the information from its cache.

With mDNS, *service discovery* is accomplished by browsing. An mDNS query is sent out for a given service type and domain, and any device that is aware of matching services replies with service information. The result is a list of available services for the user to choose from.

The mDNS protocol (mDNS-RFC), together with DNS Service Discovery (DNS-SD-RFC) achieves the zero-configuration addressing, naming, and service discovery.

## mDNS-SD

Multicast DNS Service Discovery (mDNS-SD) uses DNS protocol semantics and multicast over well-known multicast addresses to achieve zero configuration service discovery. DNS packets are sent to and received on port 5353 using a multicast address of 224.0.0.251 and its IPv6 equivalent FF02::FB.

Because mDNS uses a link-local multicast address, its scope is limited to a single physical or logical LAN. If the networking reach needs to be extended to a distributed campus or to a wide-area environment consisting of many different networking technologies, mDNS gateway is implemented. An mDNS gateway provides a transport for mDNS packets across Layer 3 boundaries by filtering, caching, and redistributing services from one Layer 3 domain to another.

### mDNS-SD Considerations for Wireless Clients

- mDNS packets can be sent out of Layer 3 interfaces that might not have an IP address.
- Packets with mDNS multicast IP and multicast MAC are sent on a multicast CAPWAP tunnel, if multicast-multicast mode is enabled. A multicast CAPWAP tunnel is a special CAPWAP tunnel used for reducing the number of copies of multicast packet that are required to be generated for each AP CAPWAP tunnel. Sending packets on the multicast CAPWAP tunnel requires the outer IP header to be destined to the multicast CAPWAP tunnel's address, which all APs are subscribed to.
- All mDNS packet handling is done at a foreign switch for roamed clients. A foreign switch is the new switch that a roamed wireless client is actually attached to, which is called the point of attachment.

## Service Discovery Gateway

The Service Discovery Gateway feature enables multicast Domain Name System (mDNS) to operate across Layer 3 boundaries (different subnets). An mDNS gateway provides transport for service discovery across Layer 3 boundaries by filtering, caching, and redistributing services from one Layer 3 domain (subnet) to another. Prior to implementation of this feature, mDNS was limited in scope to within a subnet because of the use of link-local scoped multicast addresses. This feature enhances Bring Your Own Device (BYOD).

## mDNS Gateway and Subnets

You need to enable an mDNS gateway for service discovery to operate across subnets. You can enable mDNS gateway for a device or for an interface.



**Note** You need to configure service routing globally before configuring at the interface level.

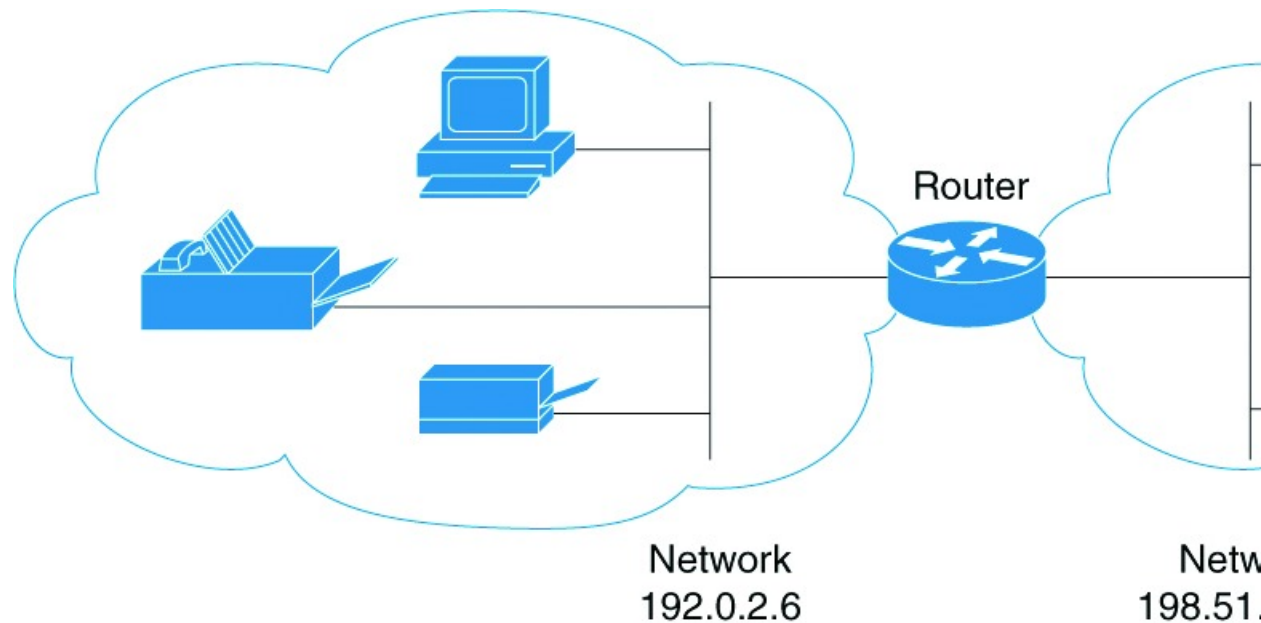
After the device or interface is enabled, you can redistribute service discovery information across subnets. You can create service policies and apply filters on either incoming service discovery information (called IN-bound filtering) or outgoing service discovery information (called OUT-bound filtering).



**Note** If redistribution is enabled globally, global configuration is given higher priority than interface configuration.

*Figure 37: Sample Networking Scenario*

For example, if the mDNS gateway functionality is enabled on the router in this figure, then service information can be sent from one subnet to another and vice-versa. For example, the printer and fax service information being advertised in the network with IP address 192.0.2.6 are redistributed to the network with IP address 198.51.100.4. The printer and fax service information in the network with IP address 192.0.2.6 is learned by mDNS-enabled hosts and devices in the other network.



## Filtering

After configuring the mDNS gateway and subnets, you can filter services that you want to redistribute. While creating a service list, the **permit** or **deny** command options are used:

- The **permit** command option allows you to permit or transport specific service list information.

- The **deny** option allows you to deny service list information that is available to be transported to other subnets.

You need to include a sequence number when using the **permit** or **deny** command option. The same service list name can be associated with multiple sequence numbers and each sequence number will be mapped to a rule.



**Note** If no filters are configured, then the default action is to deny service list information to be transported through the device or interface.

Query is another option provided when creating service lists. You can create queries using a service list. If you want to browse for a service, then active queries can be used. This function is helpful to keep the records refreshed in the cache.



**Note** Active queries can only be used globally and cannot be used at the interface level.

A service end-point (such as a printer or fax) sends unsolicited announcements when a service starts up. After that, it sends unsolicited announcements whenever a network change event occurs (such as an interface coming up or going down). The device always respond to queries.

After creating a service list and using the **permit** or **deny** command options, you can filter using match statements (commands) based on *service-instance*, *service-type*, or *message-type* (announcement or query).

## How to Configure the Service Discovery Gateway

### Configuring the Service List (CLI)

This procedure describes how to create a service list, apply a filter for the service list, and configure parameters for the service list name.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password, if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<p><b>service-list mdns-sd</b> <i>service-list-name</i> {<b>deny</b> <i>sequence-number</i>   <b>permit</b> <i>sequence-number</i>   <b>query</b>}</p> <p><b>Example:</b></p> <pre>Device(config)# <b>service-list mdns-sd s11</b> <b>permit 3</b></pre> <pre>Device(config)# <b>service-list mdns-sd s14</b> <b>query</b></pre>	<p>Enters mDNS service discovery service list mode. In this mode, you can:</p> <ul style="list-style-type: none"> <li>• Create a service list and apply a filter on the service list according to the <b>permit</b> or <b>deny</b> option applied to the sequence number.</li> <li>• Create a service list and associate a query for the service list name if the <b>query</b> option is used.</li> </ul> <p><b>Note</b> The sequence number sets the priority of the rule. A rule with a lower sequence number is selected first and the service announcement or query is allowed or denied accordingly. You define the sequence number as per your network requirements.</p>
<b>Step 4</b>	<p><b>match message-type</b> {<b>announcement</b>   <b>any</b>   <b>query</b>}</p> <p><b>Example:</b></p> <pre>Device(config-mdns-sd-sl)# <b>match</b> <b>message-type announcement</b></pre>	<p>(Optional) Sets the message type to match. You can match the following message types:</p> <ul style="list-style-type: none"> <li>• announcement</li> <li>• any</li> <li>• query</li> </ul> <p>These commands configure the parameters for the service list name that is created in step 2.</p> <p>If the <b>match message-type</b> is an announcement, then the service list rule only allows service advertisements or announcements for the device. If the <b>match message-type</b> is a query, then only a query from the client for a certain service in the network is allowed.</p> <p>Multiple service maps of the same name with different sequence numbers can be created and the evaluation of the filters will be ordered on the sequence number. Service lists are an ordered sequence of individual statements, each one has a permit or deny result. Evaluation of service list consists of a list scan, in a predetermined order, and an evaluation of the criteria of each statement that matches. A list scan is stopped once the first statement match is found and an action permit/deny associated with the statement match is performed. The</p>

	Command or Action	Purpose
		<p>default action after scanning through the entire list is to deny.</p> <p><b>Note</b> You cannot use the <b>match</b> command if you have used the <b>query</b> option in the previous step. The <b>match</b> command can be used only for the <b>permit</b> or <b>deny</b> option.</p>
<b>Step 5</b>	<p><b>match service-instance</b> { <i>LINE</i> }</p> <p><b>Example:</b></p> <pre>Device(config-mdns-sd-sl)## match service-instance servInst 1</pre>	<p>(Optional) Sets the service instance to match.</p> <p>This command configures the parameters for the service list name that is created in step 2.</p> <p><b>Note</b> You cannot use the <b>match</b> command if you have used the <b>query</b> option in the previous step. The <b>match</b> command can be used only for the <b>permit</b> or <b>deny</b> option.</p>
<b>Step 6</b>	<p><b>match service-type</b> { <i>LINE</i> }</p> <p><b>Example:</b></p> <pre>Device(config-mdns-sd-sl)# match service-type _ipp._tcp</pre>	<p>(Optional) Sets the value of the mDNS service type string to match.</p> <p>This command configures the parameters for the service list name that is created in step 2.</p> <p><b>Note</b> You cannot use the <b>match</b> command if you have used the <b>query</b> option in the previous step. The <b>match</b> command can be used only for the <b>permit</b> or <b>deny</b> option.</p>
<b>Step 7</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-mdns-sd-sl)# end</pre>	<p>Returns to privileged EXEC mode.</p>

**What to do next**

Proceed to enable the mDNS gateway and redistribution of services.

## Enabling mDNS Gateway and Redistributing Services (CLI)

After enabling mDNS gateway for a device, you can apply filters (apply IN-bound filtering or OUT-bound filtering) and active queries by using **service-policy** and **service-policy-query** commands, respectively. You can redistribute services and service announcements using the **redistribute mdns-sd** command, and set some part of the system memory for cache using the **cache-memory-max** command.





**Note** By default, mDNS gateway is disabled on all interfaces.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password, if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>service-routing mdns-sd</b> <b>Example:</b> Device (config)# <b>service-routing mdns-sd</b>	Enables mDNS gateway functionality for a device and enters multicast DNS configuration (config-mdns) mode. <b>Note</b> This command enables the mDNS function globally. <b>Note</b> Enter the <b>service-routing mdns-sd source-interface if-name</b> command in either global-config or interface-config mode, to specify an alternate source interface for outgoing mDNS packets, so its IP address can be used when there is none configured on the outgoing interface.
<b>Step 4</b>	<b>service-policy service-policy-name {IN   OUT}</b> <b>Example:</b> Device (config-mdns)# <b>service-policy serv-poll IN</b>	(Optional) For a service list, applies a filter on incoming service discovery information (IN-bound filtering) or outgoing service discovery information (OUT-bound filtering).
<b>Step 5</b>	<b>redistribute mdns-sd</b> <b>Example:</b> Device (config-mdns)# <b>redistribute mdns-sd</b>	(Optional) Redistributes services or service announcements across subnets. <b>Note</b> If redistribution is enabled globally, global configuration is given higher priority than interface configuration.

	Command or Action	Purpose
<b>Step 6</b>	<b>cache-memory-max</b> <i>cache-config-percentage</i> <b>Example:</b> <pre>Device (config-mdns)# <b>cache-memory-max</b> 20</pre>	(Optional) Sets some part of the system memory (in percentage) for cache. <b>Note</b> By default, 10 percent of the system memory is set aside for cache. You can override the default value by using this command.
<b>Step 7</b>	<b>service-policy-query</b> <i>service-list-query-name</i> <i>service-list-query-periodicity</i> <b>Example:</b> <pre>Device (config-mdns)# <b>service-policy-query</b> sl-query1 100</pre>	(Optional) Configures service list-query periodicity.
<b>Step 8</b>	<b>exit</b> <b>Example:</b> <pre>Device (config-mdns)#<b>exit</b></pre>	(Optional) Returns to global configuration mode.
<b>Step 9</b>	<b>wireless multicast</b> <b>Example:</b> <pre>Device (config)# <b>wireless multicast</b></pre>	(Optional) Enables wireless Ethernet multicast support.
<b>Step 10</b>	<b>no wireless mDNS-bridging</b> <b>Example:</b> <pre>Device (config)# <b>no wireless</b> <b>mDNS-bridging</b></pre>	(Optional) Disables bridging of mDNS packets to wireless clients.
<b>Step 11</b>	<b>end</b> <b>Example:</b> <pre>Device (config)# <b>end</b></pre>	Returns to privileged EXEC mode.

# Monitoring Service Discovery Gateway

Table 49: Monitoring Service Discovery Gateway

Command	Purpose
<code>show mdns requests [detail   name record-name   type record-type [ name record-name]]</code>	This command displays information for outstanding mDNS requests, including record name and record type information.
<code>show mdns cache [interface type number   name record-name [type record-type]   type record-type]</code>	This command displays mDNS cache information.
<code>show mdns statistics {all   service-list list-name   service-policy {all   interface type number }}</code>	This command displays mDNS statistics.

## Configuration Examples

### Example: Specify Alternative Source Interface for Outgoing mDNS Packets

The following example displays how to specify an alternate source interface for outgoing mDNS packets, so its IP address can be used when there is none configured on the outgoing interface.

```
Device(config)# service-routing mdns-sd
Device(config-mdns)# source-interface if-name
```

### Example: Redistribute Service Announcements

The following example displays how to redistribute service announcements received on one interface over all the interfaces or over a specific interface.

```
Device(config)# service-routing mdns-sd
Device(config-mdns)# Redistribute mdns-sd if-name
```

### Example: Disable Bridging of mDNS Packets to Wireless Clients

The following example displays how to disable bridging of mDNS packets to wireless clients.

```
Device(config)# wireless multicast
Device(config)# no wireless mdns-bridging
```

## Example: Creating a Service-List, Applying a Filter and Configuring Parameters

The following example shows the creation of a service-list sl1. The **permit** command option is being applied on sequence number 3 and all services with message-type announcement are filtered and available for transport across various subnets associated with the device.

```
Device# configure terminal
Device(config)# service-list mdns-sd sl1 permit 3
Device(config-mdns-sd-sl)#match message-type announcement
Device(config-mdns)# exit
```

## Example: Enabling mDNS Gateway and Redistributing Services

The following example shows how to enable an mDNS gateway for a device and enable redistribution of services across subnets. IN-bound filtering is applied on the service-list serv-poll. Twenty percent of system memory is made available for cache and service-list-query periodicity is configured at 100 seconds.

```
Device# configure terminal
Device# service-routing mdns-sd
Device(config-mdns)# service-policy serv-poll IN
Device(config-mdns)# redistribute mdns-sd
Device(config-mdns)# cache-memory-max 20
Device(config-mdns)# service-policy-query sl-query1 100
Device(config-mdns)# exit
```

## Example: Global mDNS Configuration

The following example displays how to globally configure mDNS.

```
Device# configure terminal
Device(config)# service-list mdns-sd mypermit-all permit 10
Device(config-mdns-sd-sl)# exit
Device(config)# service-list mdns-sd querier query
Device(config-mdns-sd-sl)# service-type _dns._udp
Device(config-mdns-sd-sl)# end
Device# configure terminal
Device(config)# service-routing mdns-sd
Device(config-mdns)# service-policy mypermit-all IN
Device(config-mdns)# service-policy mypermit-all OUT
```

## Example: Interface mDNS Configuration

The following example displays how to configure mDNS for an interface.

```
Device(config)#interface Vlan136
Device(config-if)# description *** Mgmt VLAN ***
Device(config-if)# ip address 9.7.136.10 255.255.255.0
Device(config-if)# ip helper-address 9.1.0.100
Device(config-if)# service-routing mdns-sd
Device(config-if-mdns-sd)# service-policy mypermit-all IN
```

```
Device(config-if-mdns-sd) # service-policy mypermit-all OUT
Device(config-if-mdns-sd) # service-policy-query querier 60
```

## Where to Go Next for Configuring Services Discovery Gateway

You can configure the following:

- IGMP
- Wireless Multicast
- PIM
- SSM
- IP Multicast Routing

## Additional References

### Related Documents

Related Topic	Document Title
Configuring DNS	<i>IP Addressing: DNS Configuration Guide, Cisco IOS XE Release 3SE</i>
DNS conceptual information	'Information About DNS' section in <i>IP Addressing: DNS Configuration Guide, Cisco IOS XE Release 3SE</i>
Platform-independent configuration information	<i>IP Addressing: DNS Configuration Guide, Cisco IOS XE Release 3SE</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### Standards and RFCs

Standard/RFC	Title
RFC 6763	<i>DNS-Based Service Discovery</i>
Multicast DNS Internet-Draft	<a href="#">Multicast</a>

**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for Services Discovery Gateway

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.



## CHAPTER 38

# IP Multicast Optimization: Optimizing PIM Sparse Mode in a Large IP Multicast Deployment

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- [Prerequisites for Optimizing PIM Sparse Mode in a Large IP Multicast Deployment, on page 665](#)
- [Information About Optimizing PIM Sparse Mode in a Large IP Multicast Deployment, on page 665](#)
- [How to Optimize PIM Sparse Mode in a Large IP Multicast Deployment, on page 669](#)
- [Configuration Examples for Optimizing PIM Sparse Mode in a Large Multicast Deployment, on page 671](#)
- [Additional References, on page 671](#)
- [Feature History and Information for Optimizing PIM Sparse Mode in a Large IP Multicast Deployment, on page 672](#)

## Prerequisites for Optimizing PIM Sparse Mode in a Large IP Multicast Deployment

- You must have PIM sparse mode running in your network.
- If you plan to use a group list to control to which groups the shortest-path tree (SPT) threshold applies, you must have configured your access list before performing the task.

## Information About Optimizing PIM Sparse Mode in a Large IP Multicast Deployment

### PIM Registering Process

IP multicast sources do not use a signaling mechanism to announce their presence. Sources just send their data into the attached network, as opposed to receivers that use Internet Group Management Protocol (IGMP) to announce their presence. If a source sends traffic to a multicast group configured in PIM sparse mode (PIM-SM), the Designated Router (DR) leading toward the source must inform the rendezvous point (RP) about the presence of this source. If the RP has downstream receivers that want to receive the multicast traffic (natively) from this source and has not joined the shortest path leading toward the source, then the DR must

send the traffic from the source to the RP. The PIM registering process, which is individually run for each (S, G) entry, accomplishes these tasks between the DR and RP.

The registering process begins when a DR creates a new (S, G) state. The DR encapsulates all the data packets that match the (S, G) state into PIM register messages and unicasts those register messages to the RP.

If an RP has downstream receivers that want to receive register messages from a new source, the RP can either continue to receive the register messages through the DR or join the shortest path leading toward the source. By default, the RP will join the shortest path, because delivery of native multicast traffic provides the highest throughput. Upon receipt of the first packet that arrives natively through the shortest path, the RP will send a register-stop message back to the DR. When the DR receives this register-stop message, it will stop sending register messages to the RP.

If an RP has no downstream receivers that want to receive register messages from a new source, the RP will not join the shortest path. Instead, the RP will immediately send a register-stop message back to the DR. When the DR receives this register-stop message, it will stop sending register messages to the RP.

Once a routing entry is established for a source, a periodic reregistering takes place between the DR and RP. One minute before the multicast routing table state times out, the DR will send one dataless register message to the RP each second that the source is active until the DR receives a register-stop message from the RP.

This action restarts the timeout time of the multicast routing table entry, typically resulting in one reregistering exchange every 2 minutes. Reregistering is necessary to maintain state, to recover from lost state, and to keep track of sources on the RP. It will take place independently of the RP joining the shortest path.

## PIM Version 1 Compatibility

If an RP is running PIM Version 1, it will not understand dataless register messages. In this case, the DR will not send dataless register messages to the RP. Instead, approximately every 3 minutes after receipt of a register-stop message from the RP, the DR encapsulates the incoming data packets from the source into register messages and sends them to the RP. The DR continues to send register messages until it receives another register-stop message from the RP. The same behavior occurs if the DR is running PIM Version 1.

When a DR running PIM Version 1 encapsulates data packets into register messages for a specific (S, G) entry, the entry is process-switched, not fast-switched or hardware-switched. On platforms that support these faster paths, the PIM registering process for an RP or DR running PIM Version 1 may lead to periodic out-of-order packet delivery. For this reason, we recommend upgrading your network from PIM Version 1 to PIM Version 2.

## PIM Designated Router

Devices configured for IP multicast send PIM hello messages to determine which device will be the designated router (DR) for each LAN segment (subnet). The hello messages contain the device's IP address, and the device with the highest IP address becomes the DR.

The DR sends Internet Group Management Protocol (IGMP) host query messages to all hosts on the directly connected LAN. When operating in sparse mode, the DR sends source registration messages to the rendezvous point (RP).

By default, multicast devices send PIM router query messages every 30 seconds. By enabling a device to send PIM hello messages more often, the device can discover unresponsive neighbors more quickly. As a result, the device can implement failover or recovery procedures more efficiently. It is appropriate to make this change only on redundant devices on the edge of the network.



## PIM Sparse-Mode Register Messages

Dataless register messages are sent at a rate of one message per second. Continuous high rates of register messages might occur if a DR is registering bursty sources (sources with high data rates) and if the RP is not running PIM Version 2.

By default, PIM sparse-mode register messages are sent without limiting their rate. Limiting the rate of register messages will limit the load on the DR and RP, at the expense of dropping those register messages that exceed the set limit. Receivers may experience data packet loss within the first second in which packets are sent from bursty sources.

## Preventing Use of Shortest-Path Tree to Reduce Memory Requirement

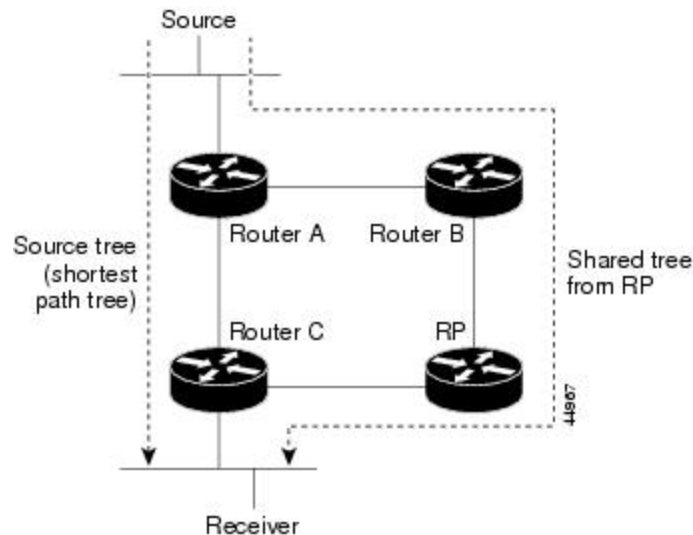
Understanding PIM shared tree and source tree will help you understand how preventing the use of the shortest-path tree can reduce memory requirements.

### PIM Shared Tree and Source Tree

By default, members of a group receive data from senders to the group across a single data-distribution tree rooted at the RP.

**Figure 38: Shared Tree and Source Tree (Shortest-Path Tree)**

The following figure shows this type of shared-distribution tree. Data from senders is delivered to the RP for distribution to group members joined to the shared tree.



If the data rate warrants, leaf routers (routers without any downstream connections) on the shared tree can use the data distribution tree rooted at the source. This type of distribution tree is called a shortest-path tree or source tree. By default, the software devices to a source tree upon receiving the first data packet from a source.

This process describes the move from a shared tree to a source tree:

1. A receiver joins a group; leaf Router C sends a join message toward the RP.
2. The RP puts a link to Router C in its outgoing interface list.

3. A source sends data; Router A encapsulates the data in a register message and sends it to the RP.
4. The RP forwards the data down the shared tree to Router C and sends a join message toward the source. At this point, data might arrive twice at Router C, once encapsulated and once natively.
5. When data arrives natively (unencapsulated) at the RP, it sends a register-stop message to Router A.
6. By default, reception of the first data packet prompts Router C to send a join message toward the source.
7. When Router C receives data on (S, G), it sends a prune message for the source up the shared tree.
8. The RP deletes the link to Router C from the outgoing interface of (S, G). The RP triggers a prune message toward the source.

Join and prune messages are sent for sources and RPs. They are sent hop-by-hop and are processed by each PIM device along the path to the source or RP. Register and register-stop messages are not sent hop-by-hop. They are sent by the designated router that is directly connected to a source and are received by the RP for the group.

Multiple sources sending to groups use the shared tree. You can configure the PIM device to stay on the shared tree.

The change from shared to source tree happens when the first data packet arrives at the last-hop router. This change depends upon the threshold that is configured by using the **ip pim spt-threshold** global configuration command.

The shortest-path tree requires more memory than the shared tree but reduces delay. You may want to postpone its use. Instead of allowing the leaf router to immediately move to the shortest-path tree, you can specify that the traffic must first reach a threshold.

You can configure when a PIM leaf router should join the shortest-path tree for a specified group. If a source sends at a rate greater than or equal to the specified kbps rate, the multilayer switch triggers a PIM join message toward the source to construct a source tree (shortest-path tree). If the traffic rate from the source drops below the threshold value, the leaf router switches back to the shared tree and sends a prune message toward the source.

You can specify to which groups the shortest-path tree threshold applies by using a group list (a standard access list). If a value of 0 is specified or if the group list is not used, the threshold applies to all groups.

#### Related Topics

[Delaying the Use of PIM Shortest-Path Tree \(CLI\)](#), on page 557

## Benefit of Preventing or Delaying the Use of the Shortest-Path Tree

The switch from shared to source tree happens upon the arrival of the first data packet at the last hop device (Router C in [PIM Shared Tree and Source Tree](#), on page 530). This switch occurs because the **ip pim spt-threshold** command controls that timing, and its default setting is 0 kbps.

The shortest-path tree requires more memory than the shared tree, but reduces delay. You might want to prevent or delay its use to reduce memory requirements. Instead of allowing the leaf device to move to the shortest-path tree immediately, you can prevent use of the SPT or specify that the traffic must first reach a threshold.

You can configure when a PIM leaf device should join the shortest-path tree for a specified group. If a source sends at a rate greater than or equal to the specified *kbps* rate, the device triggers a PIM Join message toward the source to construct a source tree (shortest-path tree). If the **infinity** keyword is specified, all sources for the specified group use the shared tree, never switching to the source tree.

# How to Optimize PIM Sparse Mode in a Large IP Multicast Deployment

## Optimizing PIM Sparse Mode in a Large Deployment

Consider performing this task if your deployment of IP multicast is large.

Steps 3, 5, and 6 in this task are independent of each other and are therefore considered optional. Any one of these steps will help optimize PIM sparse mode. If you are going to perform Step 5 or 6, you must perform Step 4. Step 6 applies only to a designated router; changing the PIM query interval is only appropriate on redundant routers on the edge of the PIM domain.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Router&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Router# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ip pim register-rate-limit <i>rate</i></b> <b>Example:</b> <pre>Router(config)# ip pim register-rate-limit 10</pre>	(Optional) Sets a limit on the maximum number of PIM sparse mode register messages sent per second for each (S, G) routing entry. <ul style="list-style-type: none"> <li>• Use this command to limit the number of register messages that the designated router (DR) will allow for each (S, G) entry.</li> <li>• By default, there is no maximum rate set.</li> <li>• Configuring this command will limit the load on the DR and RP at the expense of dropping those register messages that exceed the set limit.</li> <li>• Receivers may experience data packet loss within the first second in which register messages are sent from bursty sources.</li> </ul>
<b>Step 4</b>	<b>ip pim spt-threshold <i>{kpbs infinity}</i> [<i>group-list access-list</i>]</b> <b>Example:</b>	(Optional) Specifies the threshold that must be reached before moving to the shortest-path tree.

	Command or Action	Purpose
	<pre>Router(config)# ip pim spt-threshold infinity group-list 5</pre>	<ul style="list-style-type: none"> <li>• The default value is <b>0</b>, which causes the router to join the SPT immediately upon the first data packet it receives.</li> <li>• Specifying the <b>infinity</b> keyword causes the router never to move to the shortest-path tree; it remains on the shared tree. This keyword applies to a multicast environment of “many-to-many” communication.</li> <li>• The group list is a standard access list that controls which groups the SPT threshold applies to. If a value of 0 is specified or the group list is not used, the threshold applies to all groups.</li> <li>• In the example, group-list 5 is already configured to permit the multicast groups 239.254.2.0 and 239.254.3.0: <pre>access-list 5 permit 239.254.2.0 0.0.0.255 access-list 5 permit 239.254.3.0 0.0.0.255</pre> </li> </ul>
<b>Step 5</b>	<p><b>interface</b> <i>type number</i></p> <p><b>Example:</b></p> <pre>Router(config)# interface ethernet 0</pre>	<p>Configures an interface.</p> <ul style="list-style-type: none"> <li>• If you do not want to change the default values of the PIM SPT threshold or the PIM query interval, do not perform this step; you are done with this task.</li> </ul>
<b>Step 6</b>	<p><b>ip pim query-interval</b> <i>period</i> [msec]</p> <p><b>Example:</b></p> <pre>Router(config-if)# ip pim query-interval 1</pre>	<p>(Optional) Configures the frequency at which multicast routers send PIM router query messages.</p> <ul style="list-style-type: none"> <li>• Perform this step only on redundant routers on the edge of a PIM domain.</li> <li>• The default query interval is 30 seconds.</li> <li>• The <i>period</i> argument is in seconds unless the <b>msec</b> keyword is specified.</li> <li>• Set the query interval to a smaller number of seconds for faster convergence, but keep in mind the trade-off between faster convergence and higher CPU and bandwidth usage.</li> </ul>

# Configuration Examples for Optimizing PIM Sparse Mode in a Large Multicast Deployment

## Optimizing PIM Sparse Mode in a Large IP Multicast Deployment Example

The following example shows how to:

- Set the query interval to 1 second for faster convergence.
- Configure the router to never move to the SPT but to remain on the shared tree.
- Set a limit of 10 PIM sparse mode register messages sent per second for each (S, G) routing entry.

```
interface ethernet 0
 ip pim query-interval 1
.
.
.
!
ip pim spt-threshold infinity
ip pim register-rate-limit 10
!
```

## Additional References

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
Cisco IOS IP SLAs commands	<a href="#">Cisco IOS IP Multicast Command Reference</a>
PIM Sparse Mode concepts and configuration	“Configuring Basic IP Multicast” module or “Configuring IP Multicast in IPv6 Networks” module

### MIBs

MIB	MIBs Link
No new or modified MIBs are supported by these features, and support for existing MIBs has not been modified by these features.	To locate and download MIBs for selected platforms, Cisco IOS XE releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

## Feature History and Information for Optimizing PIM Sparse Mode in a Large IP Multicast Deployment

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.



## CHAPTER 39

# IP Multicast Optimization: Multicast Subsecond Convergence

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- [Prerequisites for Multicast Subsecond Convergence, on page 673](#)
- [Restrictions for Multicast Subsecond Convergence, on page 673](#)
- [Information About Multicast Subsecond Convergence, on page 673](#)
- [How to Configure Multicast Subsecond Convergence, on page 675](#)
- [Configuration Examples for Multicast Subsecond Convergence, on page 678](#)
- [Additional References, on page 679](#)
- [Feature History and Information for Multicast Subsecond Convergence, on page 680](#)

## Prerequisites for Multicast Subsecond Convergence

Service providers must have a multicast-enabled core in order to use the Cisco Multicast Subsecond Convergence feature.

## Restrictions for Multicast Subsecond Convergence

Devices that use the subsecond designated router (DR) failover enhancement must be able to process hello interval information arriving in milliseconds. Devices that are congested or do not have enough CPU cycles to process the hello interval can assume that the Protocol Independent Multicast (PIM) neighbor is disconnected, although this may not be the case.

## Information About Multicast Subsecond Convergence

### Benefits of Multicast Subsecond Convergence

- The scalability components improve on the efficiency of handling increases (or decreases) in service users (receivers) and service load (sources or content).
- New algorithms and processes (such as aggregated join messages, which deliver up to 1000 individual messages in a single packet) reduce the time to reach convergence by a factor of 10.

- Multicast subsecond convergence improves service availability for large multicast networks.
- Multicast users such as financial services firms and brokerages receive better quality of service (QoS), because multicast functionality is restored in a fraction of the time previously required.

## Multicast Subsecond Convergence Scalability Enhancements

The Multicast Subsecond Convergence feature provides scalability enhancements that improve on the efficiency of handling increases (or decreases) in service users (receivers) and service load (sources or content). Scalability enhancements in this release include the following:

- Improved Internet Group Management Protocol (IGMP) and PIM state maintenance through new timer management techniques
- Improved scaling of the Multicast Source Discovery Protocol (MSDP) Source-Active (SA) cache

The scalability enhancements provide the following benefits:

- Increased potential PIM multicast route (mroute), IGMP, and MSDP SA cache state capacity
- Decreased CPU usage

## PIM Router Query Messages

Multicast subsecond convergence allows you to send PIM router query messages (PIM hellos) every few milliseconds. The PIM hello message is used to locate neighboring PIM devices. Before the introduction of this feature, the device could send the PIM hellos only every few seconds. By enabling a device to send PIM hello messages more often, this feature allows the device to discover unresponsive neighbors more quickly. As a result, the device can implement failover or recovery procedures more efficiently.

## Reverse Path Forwarding

Unicast Reverse Path Forwarding (RPF) helps to mitigate problems caused by the introduction of malformed or forged IP source addresses into a network by discarding IP packets that lack a verifiable IP source address. Malformed or forged source addresses can indicate denial-of-service (DoS) attacks based on source IP address spoofing.

RPF uses access control lists (ACLs) in determining whether to drop or forward data packets that have malformed or forged IP source addresses. An option in the ACL commands allows system administrators to log information about dropped or forwarded packets. Logging information about forged packets can help in uncovering information about possible network attacks.

Per-interface statistics can help system administrators quickly discover the interface serving as the entry point for an attack on the network.

## RPF Checks

PIM is designed to forward IP multicast traffic using the standard unicast routing table. PIM uses the unicast routing table to decide if the source of the IP multicast packet has arrived on the optimal path from the source. This process, the RPF check, is protocol-independent because it is based on the contents of the unicast routing table and not on any particular routing protocol.



## Triggered RPF Checks

Multicast subsecond convergence provides the ability to trigger a check of RPF changes for mroute states. This check is triggered by unicast routing changes. By performing a triggered RPF check, users can set the periodic RPF check to a relatively high value (for example, 10 seconds) and still fail over quickly.

The triggered RPF check enhancement reduces the time needed for service to be restored after disruption, such as for single service events (for example, in a situation with one source and one receiver) or as the service scales along any parameter (for example, many sources, many receivers, and many interfaces). This enhancement decreases in time-to-converge PIM (mroute), IGMP, and MSDP (SA cache) states.

## RPF Failover

In an unstable unicast routing environment that uses triggered RPF checks, the environment could be constantly triggering RPF checks, which places a burden on the resources of the device. To avoid this problem, use the **ip multicast rpf backoff** command to prevent a second triggered RPF check from occurring for the length of time configured. That is, the PIM “backs off” from another triggered RPF check for a minimum amount of milliseconds as configured by the user.

If the backoff period expires without further routing table changes, PIM then scans for routing changes and accordingly establishes multicast RPF changes. However, if more routing changes occur during the backoff period, PIM doubles the backoff period to avoid overloading the device with PIM RPF changes while the routing table is still converging.

## Topology Changes and Multicast Routing Recovery

The Multicast Subsecond Convergence feature set enhances both enterprise and service provider network backbones by providing almost instantaneous recovery of multicast paths after unicast routing recovery.

Because PIM relies on the unicast routing table to calculate its RPF when a change in the network topology occurs, unicast protocols first need to calculate options for the best paths for traffic, and then multicast can determine the best path.

Multicast subsecond convergence allows multicast protocol calculations to finish almost immediately after the unicast calculations are completed. As a result, multicast traffic forwarding is restored substantially faster after a topology change.

## How to Configure Multicast Subsecond Convergence

### Modifying the Periodic RPF Check Interval

Perform this optional task to modify the intervals at which periodic RPF checks occur.

**Note**

Cisco recommends that you do *not* change the default values for the **ip rpf interval** command. The default values allow subsecond RPF failover. The default interval at which periodic RPF checks occur is 10 seconds.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip multicast rpf interval</b> <i>seconds</i> [ <i>list access-list</i>   <i>route-map route-map</i> ] <b>Example:</b> Device(config)# ip multicast rpf interval 10	Configures the periodic RPF check intervals to occur at a specified interval, in seconds.

## Configuring PIM RPF Failover Intervals

Perform this optional task to configure the intervals at which PIM RPF failover will be triggered by changes in the routing tables.



**Note** Cisco recommends that you do *not* modify the default values for the **ip multicast rpf backoff** command. The default values allow subsecond RPF failover.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip multicast rpf backoff</b> <i>minimum maximum</i> [ <i>disable</i> ] <b>Example:</b>	Configures the minimum and the maximum backoff intervals.

	Command or Action	Purpose
	Device(config)# ip multicast rpf backoff 100 2500	

## Modifying the PIM Router Query Message Interval

Perform this task to modify the PIM router query message interval.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>type slot / subslot / port</i> <b>Example:</b>  Device(config)# interface gigabitethernet 1/0/0	Specifies the interface and enters interface configuration mode.
<b>Step 4</b>	<b>ip pim query-interval</b> <i>period [msec]</i> <b>Example:</b>  Device(config-if)# ip pim query-interval 45	Configures the frequency at which multicast routers send PIM router query messages.

## Verifying Multicast Subsecond Convergence Configurations

Perform this task to display detailed information about and to verify information regarding the Multicast Subsecond Convergence feature.

### Procedure

#### Step 1

**enable**

**Example:**

```
Device> enable
```

Enables privileged EXEC mode.

- Enter your password if prompted.

### Step 2 `show ip pim interface` *type number*

Use this command to display information about interfaces configured for PIM.

The following is sample output from the `show ip pim interface` command:

#### Example:

```
Device# show ip pim interface GigabitEthernet 1/0/0
Address          Interface          Ver/  Nbr   Query  DR      DR
                  Mode      Count  Intvl Prior
172.16.1.4      GigabitEthernet1/0/0  v2/S   1     100 ms 1      172.16.1.4
```

### Step 3 `show ip pim neighbor`

Use this command to display the PIM neighbors discovered by the Cisco IOS XE software.

The following is sample output from the `show ip pim neighbor` command:

#### Example:

```
Device# show ip pim neighbor
PIM Neighbor Table
Neighbor      Interface          Uptime/Expires    Ver  DR
Address
172.16.1.3    GigabitEthernet1/0/0  00:03:41/250 msec v2   1 / S
```

## Configuration Examples for Multicast Subsecond Convergence

### Example Modifying the Periodic RPF Check Interval

In the following example, the `ip multicast rpf interval` has been set to 10 seconds. This command does not show up in `show running-config` output unless the interval value has been configured to be the nondefault value.

```
!
ip multicast-routing
ip multicast rpf interval 10
.
.
.
interface Ethernet0/0
 ip address 172.16.2.1 255.255.255.0
.
.
.
ip pim sparse-mode
!
```

## Example Configuring PIM RPF Failover Intervals

In the following example, the **ip multicast rpf backoff** command has been configured with a minimum backoff interval value of 100 and a maximum backoff interval value of 2500. This command does not show up in **show running-config** command output unless the interval value has been configured to be the nondefault value.

```
!
ip multicast-routing
.
.
.
ip multicast rpf backoff 100 2500
!
!
interface Ethernet0/0
 ip address 172.16.2.1 255.255.255.0
.
.
.
ip pim sparse-mode
!
```

## Modifying the PIM Router Query Message Interval Example

In the following example, the **ip pim query-interval** command has been set to 100 milliseconds. This command does not show up in **show running-config** command output unless the interval value has been configured to be the nondefault value.

```
!
interface gigabitethernet0/0/1
 ip address 172.16.2.1 255.255.255.0
ip pim query-interval 100 msec
ip pim sparse-mode
```

## Additional References

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
Cisco IOS IP SLAs commands	<a href="#">Cisco IOS IP Multicast Command Reference</a>
PIM Sparse Mode concepts and configuration	“Configuring Basic IP Multicast” module or “Configuring IP Multicast in IPv6 Networks” module

**MIBs**

MIB	MIBs Link
No new or modified MIBs are supported by these features, and support for existing MIBs has not been modified by these features.	To locate and download MIBs for selected platforms, Cisco IOS XE releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

## Feature History and Information for Multicast Subsecond Convergence

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.



## CHAPTER 40

# IP Multicast Optimization: IP Multicast Load Splitting across Equal-Cost Paths

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- [Prerequisites for IP Multicast Load Splitting across Equal-Cost Paths, on page 681](#)
- [Information about IP Multicast Load Splitting across Equal-cost Paths , on page 681](#)
- [Overview of ECMP Multicast Load Splitting, on page 684](#)
- [How to Load Split IP Multicast Traffic over ECMP, on page 691](#)
- [Configuration Examples for Load Splitting IP Multicast Traffic over ECMP, on page 698](#)
- [Additional References for IP Multicast Optimization: IP Multicast Load Splitting across Equal-Cost Paths, on page 698](#)
- [Feature History and Information for Load Splitting IP Multicast Traffic over ECMP, on page 699](#)

## Prerequisites for IP Multicast Load Splitting across Equal-Cost Paths

IP multicast is enabled on the device using the tasks described in the “Configuring Basic IP Multicast” module of the *IP Multicast: PIM Configuration Guide*.

## Information about IP Multicast Load Splitting across Equal-cost Paths

### Load Splitting Versus Load Balancing

Load splitting and load balancing are not the same. Load splitting provides a means to randomly distribute (\*, G) and (S, G) traffic streams across multiple equal-cost reverse path forwarding (RPF) paths, which does not necessarily result in a balanced IP multicast traffic load on those equal-cost RPF paths. By randomly distributing (\*, G) and (S, G) traffic streams, the methods used for load splitting IP multicast traffic attempt to distribute an equal amount of traffic flows on each of the available RPF paths not by counting the flows, but, rather, by making a pseudorandom decision. These methods are collectively referred to as equal-cost multipath (ECMP) multicast load splitting methods and result in better load-sharing in networks where there are many traffic streams that utilize approximately the same amount of bandwidth.

If there are just a few (S, G) or (\*, G) states flowing across a set of equal-cost links, the chance that they are well balanced is quite low. To overcome this limitation, precalculated source addresses--for (S, G) states or rendezvous point (RP) addresses for (\*, G) states, can be used to achieve a reasonable form of load balancing. This limitation applies equally to the per-flow load splitting in Cisco Express Forwarding (CEF) or with EtherChannels: As long as there are only a few flows, those methods of load splitting will not result in good load distribution without some form of manual engineering.

## Default Behavior for IP Multicast When Multiple Equal-Cost Paths Exist

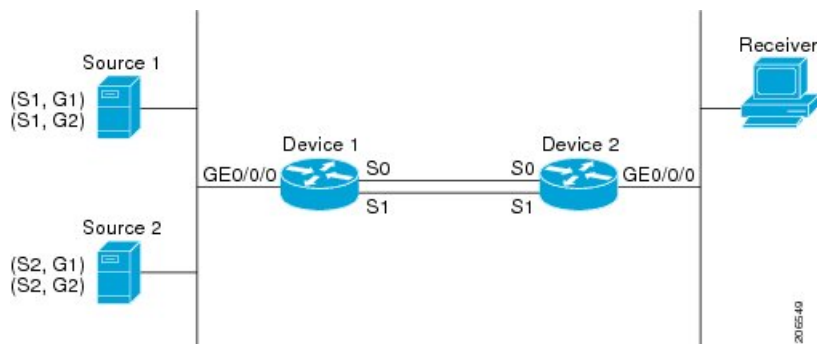
By default, for Protocol Independent Multicast sparse mode (PIM-SM), Source Specific Multicast (PIM-SSM), bidirectional PIM (bidir-PIM), groups, if multiple equal-cost paths are available, Reverse Path Forwarding (RPF) for IPv4 multicast traffic is based on the PIM neighbor with the highest IP address. This method is referred to as the highest PIM neighbor behavior. This behavior is in accordance with RFC 2362 for PIM-SM, but also applies to PIM-SSM, and bidir-PIM.

The figure illustrates a sample topology that is used in this section to explain the default behavior for IP multicast when multiple equal-cost paths exist.



**Note** Although the following illustration and example uses routers in the configuration, any device (router or switch) can be used.

**Figure 39: Default Behavior for IP Multicast When Multiple Equal-Cost Paths Exist**



In the figure, two sources, S1 and S2, are sending traffic to IPv4 multicast groups, G1 and G2. Either PIM-SM, PIM-SSM can be used in this topology. If PIM-SM is used, assume that the default of 0 for the `ip pim spt-threshold` command is being used on Device 2, that an Interior Gateway Protocol (IGP) is being run, and that the output of the `show ip route` command for S1 and for S2 (when entered on Device 2) displays serial interface 0 and serial interface 1 on Device 1 as equal-cost next-hop PIM neighbors of Device 2.

Without further configuration, IPv4 multicast traffic in the topology illustrated in the figure would always flow across one serial interface (either serial interface 0 or serial interface 1), depending on which interface has the higher IP address. For example, suppose that the IP addresses configured on serial interface 0 and serial interface 1 on Device 1 are 10.1.1.1 and 10.1.2.1, respectively. Given that scenario, in the case of PIM-SM and PIM-SSM, Device 2 would always send PIM join messages towards 10.1.2.1 and would always receive IPv4 multicast traffic on serial interface 1 for all sources and groups shown in the figure.

IPv4 RPF lookups are performed by intermediate multicast device to determine the RPF interface and RPF neighbor for IPv4 (\*,G) and (S, G) multicast routes (trees). An RPF lookup consists of RPF route-selection and route-path-selection. RPF route-selection operates solely on the IP unicast address to identify the root of



the multicast tree. For (\*, G) routes (PIM-SM and Bidir-PIM), the root of the multicast tree is the RP address for the group G; for (S, G) trees (PIM-SM, PIM-SSM), the root of the multicast tree is the source S. RPF route-selection finds the best route towards the RP or source in the routing information base (RIB), and, if configured (or available), the Distance Vector Multicast Routing Protocol (DVMRP) routing table, the Multiprotocol Border Gateway Protocol (MBGP) routing table or configured static mroutes. If the resulting route has only one available path, then the RPF lookup is complete, and the next-hop device and interface of the route become the RPF neighbor and RPF interface of this multicast tree. If the route has more than one path available, then route-path-selection is used to determine which path to choose.

For IP multicast, the following route-path-selection methods are available:



**Note** All methods but the default method of route-path-selection available in IP multicast enable some form of ECMP multicast load splitting.

- Highest PIM neighbor--This is the default method; thus, no configuration is required. If multiple equal-cost paths are available, RPF for IPv4 multicast traffic is based on the PIM neighbor with the highest IP address; as a result, without configuration, ECMP multicast load splitting is disabled by default.
- ECMP multicast load splitting method based on source address--You can configure ECMP multicast load splitting using the **ip multicast multipath** command. Entering this form of the **ip multicast multipath** command enables ECMP multicast load splitting based on source address using the S-hash algorithm. For more information, see the [ECMP Multicast Load Splitting Based on Source Address Using the S-Hash Algorithm, on page 684](#) section.
- ECMP multicast load splitting method based on source and group address--You can configure ECMP multicast load splitting using the **ip multicast multipath** command with the **s-g-hash** and **basic** keywords. Entering this form of the **ip multicast multipath** command enables ECMP multicast load splitting based on source and group address using the basic S-G-hash algorithm. For more information, see the [ECMP Multicast Load Splitting Based on Source and Group Address Using the Basic S-G-Hash Algorithm, on page 684](#) section.
- ECMP multicast load splitting method based on source, group, and next-hop address--You can configure ECMP multicast load splitting using the **ip multicast multipath** command with the **s-g-hash** and **next-hop-based** keywords. Entering this form of the command enables ECMP multicast load splitting based on source, group, and next-hop address using the next-hop-based S-G-hash algorithm. For more information, see the [ECMP Multicast Load Splitting Based on Source Group and Next-Hop Address, on page 686](#) section.

The default behavior (the highest PIM neighbor behavior) does not result in any form of ECMP load-splitting in IP multicast, but instead selects the PIM neighbor that has the highest IP address among the next-hop PIM neighbors for the available paths. A next hop is considered to be a PIM neighbor when it displays in the output of the **show ip pim neighbor** command, which is the case when PIM hello messages have been received from it and have not timed out. If none of the available next hops are PIM neighbors, then simply the next hop with the highest IP address is chosen.

## Methods to Load Split IP Multicast Traffic

In general, the following methods are available to load split IP multicast traffic:

- You can enable ECMP multicast load splitting based on source address, based on source and group address, or based on source, group, and next-hop address. After the equal-cost paths are recognized,

ECMP multicast load splitting operates on a per (S, G) basis, rather than a per packet basis as in unicast traffic.

- Alternative methods to load split IP multicast are to consolidate two or more equal-cost paths into a generic routing encapsulation (GRE) tunnel and allow the unicast routing protocol to perform the load splitting, or to load split across bundle interfaces, such as Fast or Gigabit EtherChannel interfaces, Multilink PPP (MLPPP) link bundles, or Multilink Frame Relay (FR.16) link bundles.

## Overview of ECMP Multicast Load Splitting

By default, ECMP multicast load splitting of IPv4 multicast traffic is disabled. ECMP multicast load splitting can be enabled using the `ip multicast multipath` command.

### ECMP Multicast Load Splitting Based on Source Address Using the S-Hash Algorithm

ECMP multicast load splitting traffic based on source address uses the S-hash algorithm, enabling the RPF interface for each (\*, G) or (S, G) state to be selected among the available equal-cost paths, depending on the RPF address to which the state resolves. For an (S, G) state, the RPF address is the source address of the state; for a (\*, G) state, the RPF address is the address of the RP associated with the group address of the state.

When ECMP multicast load splitting based on source address is configured, multicast traffic for different states can be received across more than just one of the equal-cost interfaces. The method applied by IPv4 multicast is quite similar in principle to the default per-flow load splitting in IPv4 CEF or the load splitting used with Fast and Gigabit EtherChannels. This method of ECMP multicast load splitting, however, is subject to polarization.

### ECMP Multicast Load Splitting Based on Source and Group Address Using the Basic S-G-Hash Algorithm

ECMP multicast load splitting based on source and group address uses a simple hash, referred to as the basic S-G-hash algorithm, which is based on source and group address. The basic S-G-hash algorithm is predictable because no randomization is used in coming up with the hash value. The S-G-hash mechanism, however, is subject to polarization because for a given source and group, the same hash is always picked irrespective of the device this hash is being calculated on.



---

**Note** The basic S-G-hash algorithm ignores bidir-PIM groups.

---

### Predictability As a By-Product of Using the S-Hash and Basic S-G-Hash Algorithms

The method used by ECMP multicast load splitting in IPv4 multicast allows for consistent load splitting in a network where the same number of equal-cost paths are present in multiple places in a topology. If an RP address or source addresses are calculated once to have flows split across N paths, then they will be split

across those N paths in the same way in all places in the topology. Consistent load splitting allows for predictability, which, in turn, enables load splitting of IPv4 multicast traffic to be manually engineered.

## Polarization As a By-Product of Using the S-Hash and Basic S-G-Hash Algorithms

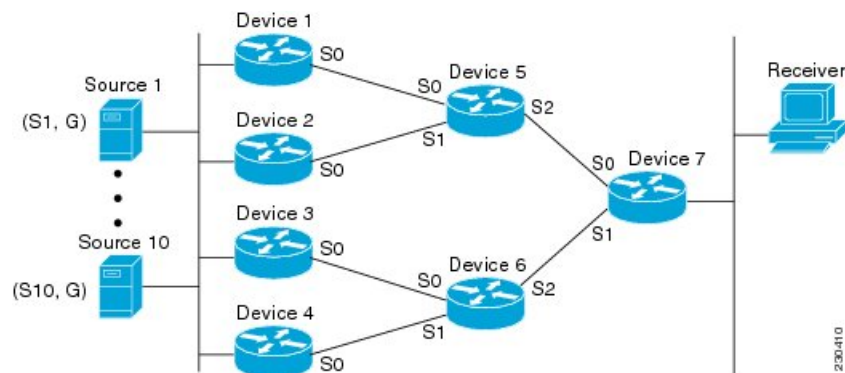
The hash mechanism used in IPv4 multicast to load split multicast traffic by source address or by source and group address is subject to a problem usually referred to as polarization. A by-product of ECMP multicast load splitting based on source address or on source and group address, polarization is a problem that prevents routers in some topologies from effectively utilizing all available paths for load splitting.

The figure illustrates a sample topology that is used in this section to explain the problem of polarization when configuring ECMP multicast load splitting based on source address or on source and group address.



**Note** Although the following illustration and example uses routers in the configuration, any device (router or switch) can be used.

**Figure 40: Polarization Topology**



In the topology illustrated in the figure, notice that Router 7 has two equal-cost paths towards the sources, S1 to S10, through Router 5 and Router 6. For this topology, suppose that ECMP multicast load splitting is enabled with the `ip multicast multipath` command on all routers in the topology. In that scenario, Router 7 would apply equal-cost load splitting to the 10 (S, G) states. The problem of polarization in this scenario would affect Router 7 because that router would end up choosing serial interface 0 on Router 5 for sources S1 to S5 and serial interface 1 on Router 6 for sources S6 to S10. The problem of polarization, furthermore, would also affect Router 5 and Router 6 in this topology. Router 5 has two equal-cost paths for S1 to S5 through serial interface 0 on Router 1 and serial interface 1 on Router 2. Because Router 5 would apply the same hash algorithm to select which of the two paths to use, it would end up using just one of these two upstream paths for sources S1 to S5; that is, either all the traffic would flow across Router 1 and Router 5 or across Router 2 and Router 5. It would be impossible in this topology to utilize Router 1 and Router 5 and Router 2 and Router 5 for load splitting. Likewise, the polarization problem would apply to Router 3 and Router 6 and Router 4 and Router 6; that is, it would be impossible in this topology to utilize both Router 3 and Router 6 and Router 4 and Router 6 for load splitting.

## ECMP Multicast Load Splitting Based on Source Group and Next-Hop Address

Configuring ECMP multicast load splitting based on source, group, and next-hop address enables a more complex hash, the next-hop-based S-G-hash algorithm, which is based on source, group, and next-hop address. The next-hop-based S-G-hash algorithm is predictable because no randomization is used in calculating the hash value. Unlike the S-hash and basic S-G-hash algorithms, the hash mechanism used by the next-hop-based S-G-hash algorithm is not subject to polarization.



---

**Note** The next-hop-based S-G-hash algorithm in IPv4 multicast is the same algorithm used in IPv6 ECMP multicast load splitting, which, in turn, utilizes the same hash function used for PIM-SM bootstrap device (BSR).

---

The next-hop-based hash mechanism does not produce polarization and also maintains better RPF stability when paths fail. These benefits come at the cost that the source or RP IP addresses cannot be used to reliably predict and engineer the outcome of load splitting when the next-hop-based S-G-hash algorithm is used. Because many customer networks have implemented equal-cost multipath topologies, the manual engineering of load splitting, thus, is not a requirement in many cases. Rather, it is more of a requirement that the default behavior of IP multicast be similar to IP unicast; that is, it is expected that IP multicast use multiple equal-cost paths on a best-effort basis. Load splitting for IPv4 multicast, therefore, could not be enabled by default because of the anomaly of polarization.



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**Note** Load splitting for CEF unicast also uses a method that does not exhibit polarization and likewise cannot be used to predict the results of load splitting or engineer the outcome of load splitting.

---

The next-hop-based hash function avoids polarization because it introduces the actual next-hop IP address of PIM neighbors into the calculation, so the hash results are different for each device, and in effect, there is no problem of polarization. In addition to avoiding polarization, this hash mechanism also increases stability of the RPF paths chosen in the face of path failures. Consider a device with four equal-cost paths and a large number of states that are load split across these paths. Suppose that one of these paths fails, leaving only three available paths. With the hash mechanism used by the polarizing hash mechanisms (the hash mechanism used by the S-hash and basic S-G-hash algorithms), the RPF paths of all states would likely reconverge and thus change between those three paths, especially those paths that were already using one of those three paths. These states, therefore, may unnecessarily change their RPF interface and next-hop neighbor. This problem exists simply because the chosen path is determined by taking the total number of paths available into consideration by the algorithm, so once a path changes, the RPF selection for all states is subject to change too. For the next-hop-based hash mechanism, only the states that were using the changed path for RPF would need to reconverge onto one of the three remaining paths. The states that were already using one of those paths would not change. If the fourth path came back up, the states that initially used it would immediately reconverge back to that path without affecting the other states.



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**Note** The next-hop-based S-G-hash algorithm ignores bidir-PIM groups.

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## Effect of ECMP Multicast Load Splitting on PIM Neighbor Query and Hello Messages for RPF Path Selection

If load splitting of IP multicast traffic over ECMP is *not* enabled and there are multiple equal-cost paths towards an RP or a source, IPv4 multicast will first elect the highest IP address PIM neighbor. A PIM neighbor is a device from which PIM hello (or PIMv1 query) messages are received. For example, consider a device that has two equal-cost paths learned by an IGP or configured through two static routes. The next hops of these two paths are 10.1.1.1 and 10.1.2.1. If both of these next-hop devices send PIM hello messages, then 10.1.2.1 would be selected as the highest IP address PIM neighbor. If only 10.1.1.1 sends PIM hello messages, then 10.1.1.1 would be selected. If neither of these devices sends PIM hello messages, then 10.1.2.1 would be selected. This deference to PIM hello messages allows the construction of certain types of dynamic failover scenarios with only static multicast routes (mroutes); it is otherwise not very useful.



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**Note** For more information about configuring static mroutes, see the [Configuring Multiple Static Mroutes in Cisco IOS](#) configuration note on the Cisco IOS IP multicast FTP site, which is available at: <ftp://ftpeng.cisco.com/ipmulticast/config-notes/static-mroutes.txt>.

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When load splitting of IP multicast traffic over ECMP is enabled, the presence of PIM hello message from neighbors is not considered; that is, the chosen RPF neighbor does not depend on whether or not PIM hello messages are received from that neighbor--it only depends on the presence or absence of an equal-cost route entry.

## Effect of ECMP Multicast Loading Splitting on Assert Processing in PIM-DM and DF Election in Bidir-PIM

The **ip multicast multipath** command only changes the RPF selection on the downstream device; it does not have an effect on designated forwarder (DF) election in bidir-PIM or the assert processing on upstream devices in PIM-DM.

The figure illustrates a sample topology that is used in this section to explain the effect of ECMP multicast load splitting on assert processing in PIM-DM and DF election in bidir-PIM.

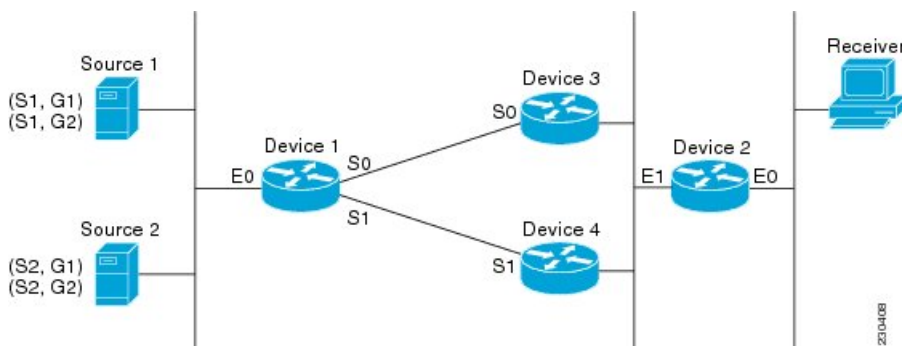


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**Note** Although the following illustration and example uses routers in the configuration, any device (router or switch) can be used.

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Figure 41: ECMP Multicast Load Splitting and Assert Processing in PIM-DM and DF Election in Bidir-PIM



In the figure, Device 2 has two equal-cost paths to S1 and S2 and the RP addresses on Device 1. Both paths are across Gigabit Ethernet interface 1/0/0: one path towards Device 3 and one path towards Device 4. For PIM-SM and PIM-SSM (\*, G) and (S, G) RPF selection, there is no difference in the behavior of Device 2 in this topology versus Device 2 in the topology illustrated in the figure. There is, however, a difference when using PIM-DM or bidir-PIM.

If PIM-DM is used in the topology illustrated in the figure, Device 3 and Device 4 would start flooding traffic for the states onto Gigabit Ethernet interface 1/0/0 and would use the PIM assert process to elect one device among them to forward the traffic and to avoid traffic duplication. As both Device 3 and Device 4 would have the same route cost, the device with the higher IP address on Gigabit Ethernet interface 1/0/0 would always win the assert process. As a result, if PIM-DM is used in this topology, traffic would not be load split across Device 3 and Device 4.

If bidir-PIM is used in the topology illustrated in the figure, a process called DF election would take place between Device 2, Device 3, and Device 4 on Gigabit Ethernet interface 1/0/0. The process of DF election would elect one device for each RP to forward traffic across Gigabit Ethernet interface 1/0/0 for any groups using that particular RP, based on the device with the highest IP address configured for that interface. Even if multiple RPs are used (for example one for G1 and another one for G2), the DF election for those RPs would always be won by the device that has the higher IP address configured on Gigabit Ethernet interface 1/0/0 (either Device 3 or Device 4 in this topology). The election rules used for DF election are virtually the same as the election rules used for the PIM assert process, only the protocol mechanisms to negotiate them are more refined for DF election (in order to return the results more expediently). As a result, when bidir-PIM is used in this topology, load splitting would always occur across Gigabit Ethernet interface 1/0/0.

The reason that ECMP multicast load splitting does influence the RPF selection but not the assert process in PIM-DM or DF election in bidir-PIM is because both the assert process and DF election are cooperative processes that need to be implemented consistently between participating devices. Changing them would require some form of protocol change that would also need to be agreed upon by the participating devices. RPF selection is a purely device local policy and, thus, can be enabled or disabled without protocol changes individually on each device.

For PIM-DM and bidir-PIM, configuring ECMP multicast load splitting with the **ip multicast multipath** command is only effective in topologies where the equal-cost paths are not upstream PIM neighbors on the same LAN, but rather neighbors on different LANs or point-to-point links.

## Effect of ECMP Multicast Load Splitting on the PIM Assert Process in PIM-SM and PIM-SSM

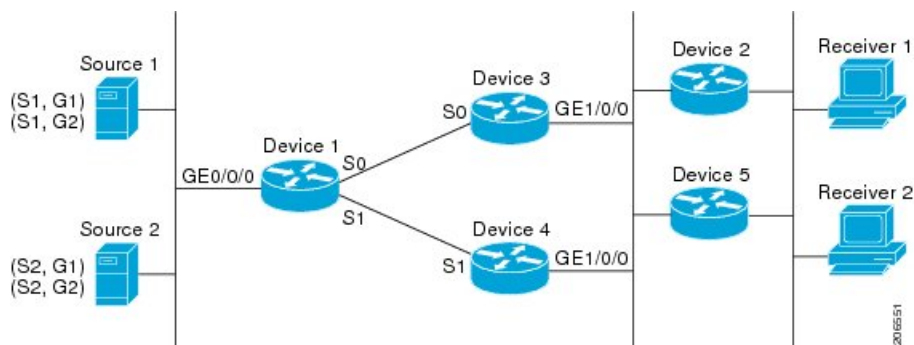
There are also cases where ECMP multicast load splitting with the **ip multicast multipath** command can become ineffective due to the PIM assert process taking over, even when using PIM-SM with (\*, G) or (S, G) forwarding or PIM-SSM with (S, G) forwarding.

The figure illustrates a sample topology that is used in this section to explain the effect of ECMP multicast load splitting on the PIM assert process in PIM-SM and PIM-SSM.



**Note** Although the following illustration and example uses routers in the configuration, any device (router or switch) can be used.

**Figure 42: ECMP Multicast Load Splitting and the PIM Assert Process in PIM-SM and PIM-SSM**



In the topology illustrated in the figure, if both Device 2 and Device 5 are Cisco devices and are consistently configured for ECMP multicast load splitting with the **ip multicast multipath** command, then load splitting would continue to work as expected; that is, both devices would have Device 3 and Device 4 as equal-cost next hops and would sort the list of equal-cost paths in the same way (by IP address). When applying the multipath hash function, for each (S, G) or (\*, G) state, they would choose the same RPF neighbor (either Device 3 or Device 4) and send their PIM joins to this neighbor.

If Device 5 and Device 2 are inconsistently configured with the **ip multicast multipath** command, or if Device 5 is a third-party device, then Device 2 and Device 5 may choose different RPF neighbors for some (\*, G) or (S, G) states. For example Device 2 could choose Device 3 for a particular (S, G) state or Device 5 could choose Device 4 for a particular (S, G) state. In this scenario, Device 3 and Device 4 would both start to forward traffic for that state onto Gigabit Ethernet interface 1/0/0, see each other's forwarded traffic, and--to avoid traffic duplication--start the assert process. As a result, for that (S, G) state, the device with the higher IP address for Gigabit Ethernet interface 1/0/0 would forward the traffic. However, both Device 2 and Device 5 would be tracking the winner of the assert election and would send their PIM joins for that state to this assert winner, even if this assert winner is not the same device as the one that they calculated in their RPF selection. For PIM-SM and PIM-SSM, therefore, the operation of ECMP multicast load splitting can only be guaranteed when all downstream devices on a LAN are consistently configured Cisco devices.

## ECMP Multicast Load Splitting and Reconvergence When Unicast Routing Changes

When unicast routing changes, all IP multicast routing states reconverge immediately based on the available unicast routing information. Specifically, if one path goes down, the remaining paths reconverge immediately, and if the path comes up again, multicast forwarding will subsequently reconverge to the same RPF paths that were used before the path failed. Reconvergence occurs whether load splitting of IP multicast traffic over ECMP is configured or not.

### Use of BGP with ECMP Multicast Load Splitting

ECMP multicast load splitting works with RPF information learned through BGP in the same way as with RPF information learned from other protocols: It chooses one path out of the multiple paths installed by the protocol. The main difference with BGP is that it only installs a single path, by default. For example, when a BGP speaker learns two identical external BGP (eBGP) paths for a prefix, it will choose the path with the lowest device ID as the best path. The best path is then installed in the IP routing table. If BGP multipath support is enabled and the eBGP paths are learned from the same neighboring AS, instead of picking the single best path, BGP installs multiple paths in the IP routing table. By default, BGP will install only one path to the IP routing table.

To leverage ECMP multicast load splitting for BGP learned prefixes, you must enable BGP multipath. Once configured, when BGP installs the remote next-hop information, RPF lookups will execute recursively to find the best next hop towards that BGP next hop (as in unicast). If for example there is only a single BGP path for a given prefix, but there are two IGP paths to reach that BGP next hop, then multicast RPF will correctly load split between the two different IGP paths.

### Use of ECMP Multicast Load Splitting with Static Mroutes

If it is not possible to use an IGP to install equal cost routes for certain sources or RPs, static routes can be configured to specify the equal-cost paths for load splitting. You cannot use static mroutes to configure equal-cost paths because the software does not support the configuration of one static mroute per prefix. There are some workarounds for this limitation using recursive route lookups but the workarounds cannot be applied to equal-cost multipath routing.



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**Note** For more information about configuring static mroutes, see the [Configuring Multiple Static Mroutes in Cisco IOS](http://ftpeng.cisco.com/ipmulticast/config-notes/static-mroutes.txt) configuration note on the Cisco IOS IP multicast FTP site at [ftp://ftpeng.cisco.com/ipmulticast/config-notes/static-mroutes.txt](http://ftpeng.cisco.com/ipmulticast/config-notes/static-mroutes.txt).

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You can specify only static mroutes for equal-cost multipaths in IPv4 multicast; however, those static mroutes would only apply to multicast, or you can specify that the equal-cost multipaths apply to both unicast and multicast routing. In IPv6 multicast, there is no such restriction. Equal-cost multipath mroutes can be configured for static IPv6 mroutes that apply to only unicast routing, only multicast routing, or both unicast and multicast routing.



## Alternative Methods of Load Splitting IP Multicast Traffic

Load splitting of IP multicast traffic can also be achieved by consolidating multiple parallel links into a single tunnel over which the multicast traffic is then routed. This method of load splitting is more complex to configure than ECMP multicast load splitting. One such case where configuring load splitting across equal-cost paths using GRE links can be beneficial is the case where the total number of (S, G) or (\*, G) states is so small and the bandwidth carried by each state so variable that even the manual engineering of the source or RP addresses cannot guarantee the appropriate load splitting of the traffic.



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**Note** With the availability of ECMP multicast load splitting, tunnels typically only need to be used if per-packet load sharing is required.

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IP multicast traffic can also be used to load split across bundle interfaces, such as Fast or Gigabit EtherChannel interfaces, MLPPP link bundles or Multilink Frame Relay (FRF.16) bundles. GRE or other type of tunnels can also constitute such forms of Layer 2 link bundles. Before using such an Layer 2 mechanism, it is necessary to understand how unicast and multicast traffic is load split.

Before load splitting IP multicast traffic across equal-cost paths over a tunnel, you must configure CEF per-packet load balancing or else the GRE packets will not be load balanced per packet.

## How to Load Split IP Multicast Traffic over ECMP

### Enabling ECMP Multicast Load Splitting

Perform the following tasks to load split IP multicast traffic across multiple equal-cost paths, based on source address.

If two or more equal-cost paths from a source are available, unicast traffic will be load split across those paths. However, by default, multicast traffic is not load split across multiple equal-cost paths. In general, multicast traffic flows down from the RPF neighbor. According to PIM specifications, this neighbor must have the highest IP address if more than one neighbor has the same metric.

Configuring load splitting with the **ip multicast multipath** command causes the system to load split multicast traffic across multiple equal-cost paths based on source address using the S-hash algorithm. When the **ip multicast multipath** command is configured and multiple equal-cost paths exist, the path in which multicast traffic will travel is selected based on the source IP address. Multicast traffic from different sources will be load split across the different equal-cost paths. Load splitting will not occur across equal-cost paths for multicast traffic from the same source sent to different multicast groups.



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**Note** The **ip multicast multipath** command load splits the traffic and does not load balance the traffic. Traffic from a source will use only one path, even if the traffic far outweighs traffic from other sources.

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### Prerequisites for IP Multicast Load Splitting - ECMP

- You must have an adequate number of sources (at least more than two sources) to enable ECMP multicast load splitting based on source address.

- You must have multiple paths available to the RP to configure ECMP multicast load splitting.




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**Note** Use the **show ip route** command with either the IP address of the source for the *ip-address* argument or the IP address of the RP to validate that there are multiple paths available to the source or RP, respectively. If you do not see multiple paths in the output of the command, you will not be able to configure ECMP multicast load splitting.

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- When using PIM-SM with shortest path tree (SPT) forwarding, the T-bit must be set for the forwarding of all (S, G) states.
- Before configuring ECMP multicast load splitting, it is best practice to use the **show ip rpf** command to validate whether sources can take advantage of IP multicast multipath capabilities.
- BGP does not install multiple equal-cost paths by default. Use the **maximum-paths** command to configure multipath (for example in BGP). For more information, see the [Use of BGP with ECMP Multicast Load Splitting, on page 690](#) section.

## Restrictions for IP Multicast Load Splitting - ECMP

- If two or more equal-cost paths from a source are available, unicast traffic will be load split across those paths. However, by default, multicast traffic is not load split across multiple equal-cost paths. In general, multicast traffic flows down from the RPF neighbor. According to PIM specifications, this neighbor must have the highest IP address if more than one neighbor has the same metric.
- The **ip multicast multipath** command does not support configurations in which the same PIM neighbor IP address is reachable through multiple equal-cost paths. This situation typically occurs if unnumbered interfaces are used. Use different IP addresses for all interfaces when configuring the **ip multicast multipath** command.
- The **ip multicast multipath** command load splits the traffic and does not load balance the traffic. Traffic from a source will use only one path, even if the traffic far outweighs traffic from other sources.

## Enabling ECMP Multicast Load Splitting Based on Source Address

Perform this task to enable ECMP multicast load splitting of multicast traffic based on source address (using the S-hash algorithm) to take advantage of multiple paths through the network. The S-hash algorithm is predictable because no randomization is used in calculating the hash value. The S-hash algorithm, however, is subject to polarization because for a given source, the same hash is always picked irrespective of the device on which the hash is being calculated.




---

**Note** Enable ECMP multicast load splitting on the device that is to be the receiver for traffic from more than one incoming interfaces, which is opposite to unicast routing. From the perspective of unicast, multicast is active on the sending device connecting to more than one outgoing interfaces.

---

**Before you begin**

- You must have an adequate number of sources (at least more than two sources) to enable ECMP multicast load splitting based on source address.
- You must have multiple paths available to the RP to configure ECMP multicast load splitting.



**Note** Use the **show ip route** command with either the IP address of the source for the *ip-address* argument or the IP address of the RP to validate that there are multiple paths available to the source or RP, respectively. If you do not see multiple paths in the output of the command, you will not be able to configure ECMP multicast load splitting.

- When using PIM-SM with shortest path tree (SPT) forwarding, the T-bit must be set for the forwarding of all (S, G) states.
- Before configuring ECMP multicast load splitting, it is best practice to use the **show ip rpf** command to validate whether sources can take advantage of IP multicast multipath capabilities.
- BGP does not install multiple equal-cost paths by default. Use the **maximum-paths** command to configure multipath (for example in BGP). For more information, see the [Use of BGP with ECMP Multicast Load Splitting, on page 690](#) section.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip multicast multipath</b> <b>Example:</b> Device(config)# ip multicast multipath	Enables ECMP multicast load splitting based on source address using the S-hash algorithm. <ul style="list-style-type: none"> <li>• Because this command changes the way an RPF neighbor is selected, it must be configured consistently on all devices in a redundant topology to avoid looping.</li> <li>• This command does not support configurations in which the same PIM neighbor IP address is reachable through multiple equal-cost paths. This situation typically occurs if unnumbered interfaces are used. Use a different IP address for</li> </ul>

	Command or Action	Purpose
		<p>each interface in a device on which this command is to be configured.</p> <ul style="list-style-type: none"> <li>This command load splits the traffic and does not load balance the traffic. Traffic from a source will use only one path, even if the traffic far outweighs traffic from other sources.</li> </ul>
<b>Step 4</b>	Repeat step 3 on all the devices in a redundant topology.	--
<b>Step 5</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config)# exit</pre>	Exits global configuration mode and returns to privileged EXEC mode.
<b>Step 6</b>	<p><b>show ip rpf <i>source-address</i> [<i>group-address</i>]</b></p> <p><b>Example:</b></p> <pre>Device# show ip rpf 10.1.1.2</pre>	<p>(Optional) Displays the information that IP multicast routing uses to perform the RPF check.</p> <ul style="list-style-type: none"> <li>Use this command to verify RPF selection so as to ensure that IP multicast traffic is being properly load split.</li> </ul>
<b>Step 7</b>	<p><b>show ip route <i>ip-address</i></b></p> <p><b>Example:</b></p> <pre>Device# show ip route 10.1.1.2</pre>	<p>(Optional) Displays the current state of the IP routing table.</p> <ul style="list-style-type: none"> <li>Use this command to verify that there are multiple paths available to a source or RP for ECMP multicast load splitting.</li> <li>For the <i>ip-address</i> argument, enter the IP address of a source to validate that there are multiple paths available to the source (for shortest path trees) or the IP address of an RP to validate that there are multiple paths available to the RP (for shared trees).</li> </ul>

## Enabling ECMP Multicast Load Splitting Based on Source and Group Address

Perform this task to enable ECMP multicast load splitting of multicast traffic based on source and group address (using the basic S-G-hash algorithm) to take advantage of multiple paths through the network. The basic S-G-hash algorithm is predictable because no randomization is used in calculating the hash value. The basic S-G-hash algorithm, however, is subject to polarization because for a given source and group, the same hash is always picked irrespective of the device on which the hash is being calculated.

The basic S-G-hash algorithm provides more flexible support for ECMP multicast load splitting than the the S-hash algorithm. Using the basic S-G-hash algorithm for load splitting, in particular, enables multicast traffic from devices that send many streams to groups or that broadcast many channels, such as IPTV servers or MPEG video servers, to be more effectively load split across equal-cost paths.



**Note** Enable ECMP multicast load splitting on the device that is to be the receiver for traffic from more than one incoming interfaces, which is opposite to unicast routing. From the perspective of unicast, multicast is active on the sending device connecting to more than one outgoing interfaces.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip multicast multipath s-g-hash basic</b> <b>Example:</b> Device(config)# ip multicast multipath s-g-hash basic	Enables ECMP multicast load splitting based on source and group address using the basic S-G-hash algorithm. <ul style="list-style-type: none"> <li>• Because this command changes the way an RPF neighbor is selected, it must be configured consistently on all devices in a redundant topology to avoid looping.</li> </ul>
<b>Step 4</b>	Repeat Step 3 on all the devices in a redundant topology.	--
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config)# exit	Exits global configuration mode and returns to privileged EXEC mode.
<b>Step 6</b>	<b>show ip rpf source-address [group-address]</b> <b>Example:</b> Device# show ip rpf 10.1.1.2	(Optional) Displays the information that IP multicast routing uses to perform the RPF check. <ul style="list-style-type: none"> <li>• Use this command to verify RPF selection so as to ensure that IP multicast traffic is being properly load split.</li> </ul>
<b>Step 7</b>	<b>show ip route ip-address</b> <b>Example:</b> Device# show ip route 10.1.1.2	(Optional) Displays the current state of the IP routing table. <ul style="list-style-type: none"> <li>• Use this command to verify that there are multiple paths available to a source or RPF for ECMP multicast load splitting.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>For the <i>ip-address</i> argument, enter the IP address of a source to validate that there are multiple paths available to the source (for shortest path trees) or the IP address of an RP to validate that there are multiple paths available to the RP (for shared trees).</li> </ul>

## Enabling ECMP Multicast Load Splitting Based on Source Group and Next-Hop Address

Perform this task to enable ECMP multicast load splitting of multicast traffic based on source, group, and next-hop address (using the next-hop-based S-G-hash algorithm) to take advantage of multiple paths through the network. The next-hop-based S-G-hash algorithm is predictable because no randomization is used in calculating the hash value. Unlike the S-hash and basic S-G-hash algorithms, the hash mechanism used by the next-hop-based S-G-hash algorithm is not subject to polarization.

The next-hop-based S-G-hash algorithm provides more flexible support for ECMP multicast load splitting than S-hash algorithm and eliminates the polarization problem. Using the next-hop-based S-G-hash algorithm for ECMP multicast load splitting enables multicast traffic from devices that send many streams to groups or that broadcast many channels, such as IPTV servers or MPEG video servers, to be more effectively load split across equal-cost paths.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Router&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Router# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ip multicast multipath s-g-hash next-hop-based</b> <b>Example:</b> <pre>Router(config)# ip multicast multipath s-g-hash next-hop-based</pre>	Enables ECMP multicast load splitting based on source, group, and next-hop-address using the next-hop-based S-G-hash algorithm. <ul style="list-style-type: none"> <li>Because this command changes the way an RPF neighbor is selected, it must be configured consistently on all routers in a redundant topology to avoid looping.</li> </ul>

	Command or Action	Purpose
		<p><b>Note</b> Be sure to enable the <b>ip multicast multipath</b> command on the router that is supposed to be the receiver for traffic from more than one incoming interfaces, which is opposite to unicast routing. From the perspective of unicast, multicast is active on the sending router connecting to more than one outgoing interfaces.</p>
<b>Step 4</b>	Repeat Steps 1 through 3 on all the routers in a redundant topology.	--
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Router(config)# end</pre>	Exits global configuration mode and returns to privileged EXEC mode.
<b>Step 6</b>	<p><b>show ip rpf <i>source-address</i> [<i>group-address</i>]</b></p> <p><b>Example:</b></p> <pre>Router# show ip rpf 10.1.1.2</pre>	<p>(Optional) Displays the information that IP multicast routing uses to perform the RPF check.</p> <ul style="list-style-type: none"> <li>• Use this command to verify RPF selection so as to ensure that IP multicast traffic is being properly load split.</li> </ul>
<b>Step 7</b>	<p><b>show ip route <i>ip-address</i></b></p> <p><b>Example:</b></p> <pre>Router# show ip route 10.1.1.2</pre>	<p>(Optional) Displays the current state of the IP routing table.</p> <ul style="list-style-type: none"> <li>• Use this command to verify that there are multiple paths available to a source or RP for ECMP multicast load splitting.</li> <li>• For the <i>ip-address</i> argument, enter the IP address of a source to validate that there are multiple paths available to the source (for shortest path trees) or the IP address of an RP to validate that there are multiple paths available to the RP (for shared trees).</li> </ul>

# Configuration Examples for Load Splitting IP Multicast Traffic over ECMP

## Example Enabling ECMP Multicast Load Splitting Based on Source Address

The following example shows how to enable ECMP multicast load splitting on a router based on source address using the S-hash algorithm:

```
ip multicast multipath
```

## Example Enabling ECMP Multicast Load Splitting Based on Source and Group Address

The following example shows how to enable ECMP multicast load splitting on a router based on source and group address using the basic S-G-hash algorithm:

```
ip multicast multipath s-g-hash basic
```

## Example Enabling ECMP Multicast Load Splitting Based on Source Group and Next-Hop Address

The following example shows how to enable ECMP multicast load splitting on a router based on source, group, and next-hop address using the next-hop-based S-G-hash algorithm:

```
ip multicast multipath s-g-hash next-hop-based
```

# Additional References for IP Multicast Optimization: IP Multicast Load Splitting across Equal-Cost Paths

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>

### Standards and RFCs

Standard/RFC	Title
<i>RFC 4601</i>	<a href="#">Protocol Independent Multicast-Sparse Mode (PIM-SM): Protocol Specification</a>



**MIBs**

MIB	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing standards has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for Load Splitting IP Multicast Traffic over ECMP

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.





## CHAPTER 41

# IP Multicast Optimization: SSM Channel Based Filtering for Multicast

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- [Prerequisites for SSM Channel Based Filtering for Multicast Boundaries, on page 701](#)
- [Information About the SSM Channel Based Filtering for Multicast Boundaries Feature, on page 701](#)
- [How to Configure SSM Channel Based Filtering for Multicast Boundaries, on page 702](#)
- [Configuration Examples for SSM Channel Based Filtering for Multicast Boundaries, on page 703](#)
- [Additional References, on page 704](#)
- [Feature History and Information for SSM Channel Based Filtering for Multicast Boundaries, on page 705](#)

## Prerequisites for SSM Channel Based Filtering for Multicast Boundaries

IP multicast is enabled on the device using the tasks described in the "Configuring Basic IP Multicast" module of the *IP Multicast: PIM Configuration Guide*.

## Information About the SSM Channel Based Filtering for Multicast Boundaries Feature

### Rules for Multicast Boundaries

The SSM Channel Based Filtering for Multicast Boundaries feature expands the **ip multicast boundary** command for control plane filtering support. More than one **ip multicast boundary** command can be applied to an interface.

The following rules govern the **ip multicast boundary** command:

- One instance of the **in** and **out** keywords can be configured on an interface.
- The **in** and **out** keywords can be used for standard or extended access lists.
- Only standard access lists are permitted with the use of the **filter-autorp** keyword or no keyword.

- A maximum of three instances of a command will be allowed on an interface: one instance of **in**, one instance of **out**, and one instance of **filter-autorp** or no keyword.
- When multiple instances of the command are used, the filtering will be cumulative. If a boundary statement with no keyword exists with a boundary statement with the **in** keyword, both access lists will be applied on the in direction and a match on either one will be sufficient.
- All instances of the command apply to both control and data plane traffic.
- Protocol information on the extended access list is parsed to allow reuse and filtering for consistency. An (S,G) operation will be filtered by an extended access list under all conditions stated above for keywords if the access list filters (S,G) traffic for all protocols.

## Benefits of SSM Channel Based Filtering for Multicast Boundaries

- This feature allows input on the source interface.
- The access control capabilities are the same for SSM and Any Source Multicast (ASM).

# How to Configure SSM Channel Based Filtering for Multicast Boundaries

## Configuring Multicast Boundaries

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip access-list {standard  extended}</b> <i>access-list-name</i> <b>Example:</b>  Device(config)# ip access-list 101	Configures the standard or extended access list.
<b>Step 4</b>	<b>permit protocol host address host</b> <i>address</i>	Permits specified ip host traffic.

	Command or Action	Purpose
	<b>Example:</b>  Device(config-ext-nacl)# permit ip host 181.1.2.201 host 232.1.1.11	
<b>Step 5</b>	<b>deny protocol host address host address</b>  <b>Example:</b>  Device(config-acl-nacl)# deny ip host 181.1.2.203 host 232.1.1.1	Denies specified multicast ip group and source traffic.
<b>Step 6</b>	Repeat Step 4 or Step 5 as needed.	Permits and denies specified host and source traffic.
<b>Step 7</b>	<b>interface type interface-number port -number</b>  <b>Example:</b>  Device(config)# interface gigabitethernet 2/3/0	Enables interface configuration mode.
<b>Step 8</b>	<b>ip multicast boundary access-list-name [in  out   filter-autorp]</b>  <b>Example:</b>  Device(config-if)# ip multicast boundary acc_grp1 out	Configures the multicast boundary.  <b>Note</b> The <b>filter-autorp</b> keyword does not support extended access lists.

## Configuration Examples for SSM Channel Based Filtering for Multicast Boundaries

### Configuring the Multicast Boundaries Permitting and Denying Traffic Example

The following example permits outgoing traffic for (181.1.2.201, 232.1.1.1) and (181.1.2.202, 232.1.1.1) and denies all other (S,G)s.

```
configure terminal
ip access-list extended acc_grp1
permit ip host 0.0.0.0 232.1.1.1 0.0.0.255
permit ip host 181.1.2.201 host 232.1.1.1
permit udp host 181.1.2.202 host 232.1.1.1
permit ip host 181.1.2.202 host 232.1.1.1
deny igmp host 181.2.3.303 host 232.1.1.1
interface gigabitethernet 2/3/0
ip multicast boundary acc_grp1 out
```

## Configuring the Multicast Boundaries Permitting Traffic Example

The following example permits outgoing traffic for (192.168.2.201, 232.1.1.5) and 192.168.2.202, 232.1.1.5).

```
configure terminal
ip access-list extended acc_grp6
 permit ip host 0.0.0.0 232.1.1.1 5.0.0.255
 deny udp host 192.168.2.201 host 232.1.1.5
 permit ip host 192.168.2.201 host 232.1.1.5
 deny pim host 192.168.2.201 host 232.1.1.5
 permit ip host 192.168.2.202 host 232.1.1.5
 deny igmp host 192.2.3.303 host 232.1.1.1
interface gigabitethernet 2/3/0
 ip multicast boundary acc_grp6 out
```

## Configuring the Multicast Boundaries Denying Traffic Example

The following example denies a group-range that is announced by the candidate RP. Because the group range is denied, no pim auto-rp mappings are created.

```
configure terminal
ip access-list standard acc_grp10
 deny 225.0.0.0 0.255.255.255
 permit any
access-list extended acc_grp12
 permit pim host 181.1.2.201 host 232.1.1.8
 deny udp host 181.1.2.201 host 232.1.1.8
 permit pim host 181.1.2.203 0.0.0.255 host 227.7.7.7
 permit ip host 0.0.0.0 host 227.7.7.7
 permit ip 181.1.2.203 0.0.0.255 host 227.7.7.7
 permit ip host 181.1.2.201 host 232.1.1.7
ip access-list extended acc_grp13
 deny ip host 181.1.2.201 host 232.1.1.8
 permit ip any any
interface gigabitethernet 2/3/0
 ip multicast boundary acc_grp10 filter-autorp
 ip multicast boundary acc_grp12 out
 ip multicast boundary acc_grp13 in
```

## Additional References

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
Cisco IOS IP Multicast commands	<a href="#">Cisco IOS IP Multicast Command Reference</a>

**MIBs**

MIB	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing standards has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS XE releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

## Feature History and Information for SSM Channel Based Filtering for Multicast Boundaries

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.







## CHAPTER 42

# IP Multicast Optimization: PIM Dense Mode State Refresh

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- [Prerequisite for PIM Dense Mode State Refresh, on page 707](#)
- [Restrictions on PIM Dense Mode State Refresh, on page 707](#)
- [Information About PIM Dense Mode State Refresh, on page 707](#)
- [How to Configure PIM Dense Mode State Refresh, on page 708](#)
- [Configuration Examples for PIM Dense Mode State Refresh, on page 710](#)
- [Additional References, on page 711](#)
- [Feature History and Information for PIM Dense Mode State Refresh, on page 712](#)

## Prerequisite for PIM Dense Mode State Refresh

- You must have PIM dense mode enabled on an interface before configuring the PIM Dense Mode State Refresh feature.

## Restrictions on PIM Dense Mode State Refresh

- All routers in a PIM dense mode network must run a software release that supports the PIM Dense Mode State Refresh feature to process and forward state refresh control messages.
- The origination interval for the state refresh control message must be the same for all PIM routers on the same LAN. Specifically, the same origination interval must be configured on each router interface that is directly connected to the LAN.

## Information About PIM Dense Mode State Refresh

### PIM Dense Mode State Refresh Overview

The PIM Dense Mode State Refresh feature is an extension of the PIM Version 2 multicast routing architecture.

PIM dense mode builds source-based multicast distribution trees that operate on a flood and prune principle. Multicast packets from a source are flooded to all areas of a PIM dense mode network. PIM routers that receive multicast packets and have no directly connected multicast group members or PIM neighbors send a prune message back up the source-based distribution tree toward the source of the packets. As a result, subsequent multicast packets are not flooded to pruned branches of the distribution tree. However, the pruned state in PIM dense mode times out approximately every 3 minutes and the entire PIM dense mode network is reflooded with multicast packets and prune messages. This reflooding of unwanted traffic throughout the PIM dense mode network consumes network bandwidth.

The PIM Dense Mode State Refresh feature keeps the pruned state in PIM dense mode from timing out by periodically forwarding a control message down the source-based distribution tree. The control message refreshes the prune state on the outgoing interfaces of each router in the distribution tree.

## Benefits of PIM Dense Mode State Refresh

The PIM Dense Mode State Refresh feature keeps the pruned state in PIM dense mode from timing out, which saves network bandwidth by greatly reducing the reflooding of unwanted multicast traffic to pruned branches of the PIM dense mode network. This feature also enables PIM routers in a PIM dense mode multicast network to recognize topology changes (sources joining or leaving a multicast group) before the default 3-minute state refresh timeout period.

## How to Configure PIM Dense Mode State Refresh

### Configuring PIM Dense Mode State Refresh

There are no configuration tasks for enabling the PIM Dense Mode State Refresh feature. By default, all PIM routers that are running a Cisco IOS XE software release that supports the PIM Dense Mode State Refresh feature automatically process and forward state refresh control messages.

To disable the processing and forwarding of state refresh control messages on a PIM router, use the **ip pim state-refresh disable** global configuration command. To enable state refresh again if it has been disabled, use the **no ip pim state-refresh disable** global configuration command.

The origination of state refresh control messages is disabled by default. To configure the origination of the control messages on a PIM router, use the following commands beginning in global configuration mode:

Command	Purpose
Router(config)# <b>interface</b> <i>type number</i>	Specifies an interface and places the router in interface configuration mode.
Router(config-if)# <b>ip pim state-refresh origination-interval</b> [ <i>interval</i> ]	Configures the origination of the PIM Dense Mode State Refresh control message. Optionally, you can configure the number of seconds between control messages by using the <i>interval</i> argument. The default interval is 60 seconds. The interval range is 1 second to 100 seconds.

## Verifying PIM Dense Mode State Refresh Configuration

Use the `show ip pim interface [type number] detail` and the `show ip pim neighbor [interface]` commands to verify that the PIM Dense Mode State Refresh feature is configured correctly. The following output of the `show ip pim interface [type number] detail` command indicates that processing, forwarding, and origination of state refresh control messages is enabled.

```
Router# show ip pim interface fastethernet 0/1/0 detail
FastEthernet0/1/0 is up, line protocol is up
  Internet address is 172.16.8.1/24
  Multicast switching:process
  Multicast packets in/out:0/0
  Multicast boundary:not set
  Multicast TTL threshold:0
  PIM:enabled
    PIM version:2, mode:dense
    PIM DR:172.16.8.1 (this system)
    PIM neighbor count:0
    PIM Hello/Query interval:30 seconds
  PIM State-Refresh processing:enabled
  PIM State-Refresh origination:enabled, interval:60 seconds
  PIM NBMA mode:disabled
  PIM ATM multipoint signalling:disabled
  PIM domain border:disabled
  Multicast Tagswitching:disabled
```

The S in the Mode field of the following `show ip pim neighbor [interface]` command output indicates that the neighbor has the PIM Dense Mode State Refresh feature configured.

```
Router# show ip pim neighbor
PIM Neighbor Table
Neighbor          Interface          Uptime/Expires    Ver  DR
Address                                     Priority/Mode
172.16.5.1         Ethernet1/1        00:09:03/00:01:41 v2   1 / B S
```

## Monitoring and Maintaining PIM DM State Refresh

Following are the PIM Dense Mode State Refresh control messages that are sent and received by a PIM router after the `debug ip pim` privileged EXEC command is configured for multicast group 239.0.0.1:

```
Router# debug ip pim 239.0.0.1
*Mar 1 00:25:10.416:PIM:Originating refresh message for
(172.16.8.3,239.0.0.1)
*Mar 1 00:25:10.416:PIM:Send SR on GigabitEthernet1/1/0 for (172.16.8.3,239.0.0.1)
TTL=9
```

The following output from the `show ip mroute` command displays are the resulting prune timer changes for GigabitEthernet interface 1/0/0 and multicast group 239.0.0.1. (The following output assumes that the `debug ip pim` privileged EXEC command has already been configured on the router.) In the first output from the `show ip mroute` command, the prune timer reads 00:02:06. The debug messages indicate that a PIM Dense Mode State Refresh control message is received and sent on Ethernet interface 1/0, and that other PIM Dense Mode State Refresh routers were discovered. In the second output from the `show ip mroute` command, the prune timer has been reset to 00:02:55.

```
Router# show ip mroute 239.0.0.1
(172.16.8.3, 239.0.0.1), 00:09:50/00:02:06, flags:PT
```

```

    Incoming interface:GigabitEthernet1/1/0, RPF nbr 172.16.5.2
    Outgoing interface list:
GigabitEthernet1/0/0, Prune/Dense, 00:09:43/00:02:06
Router#
*Mar  1 00:32:06.657:PIM:SR on iif from 172.16.5.2 orig 172.16.8.1 for
(172.16.8.3,239.0.0.1)
*Mar  1 00:32:06.661:      flags:prune-indicator
*Mar  1 00:32:06.661:PIM:Cached metric is [0/0]
*Mar  1 00:32:06.661:PIM:Keep RPF nbr 172.16.5.2
*Mar  1 00:32:06.661:PIM:Send SR on Ethernet1/0 for (172.16.8.3,239.0.0.1)
TTL=8
*Mar  1 00:32:06.661:      flags:prune-indicator
Router# show ip mroute 239.0.0.1
(172.16.8.3, 239.0.0.1), 00:10:01/00:02:55, flags:PT
    Incoming interface:GigabitEthernet1/1/0, RPF nbr 172.16.5.2
    Outgoing interface list:
GigabitEthernet1/0/0, Prune/Dense, 00:09:55/00:02:55

```

## Configuration Examples for PIM Dense Mode State Refresh

### Originating Processing and Forwarding PIM Dense Mode State Refresh Control Messages Example

The following example is for a PIM router that is originating, processing, and forwarding PIM Dense Mode State Refresh control messages on Fast Ethernet interface 0/1/0 every 60 seconds:

```

ip multicast-routing distributed
interface FastEthernet0/1/0
 ip address 172.16.8.1 255.255.255.0
 ip pim state-refresh origination-interval 60
 ip pim dense-mode

```

### Processing and Forwarding PIM Dense Mode State Refresh Control Messages Example

The following example is for a PIM router that is just processing and forwarding PIM Dense Mode State Refresh control messages on Fast Ethernet interface 1/1/0:

```

ip multicast-routing
interface FastEthernet1/1/0
 ip address 172.16.7.3 255.255.255.0
 ip pim dense-mode

```

# Additional References

## Related Documents

Related Topic	Document Title
The PIM Dense Mode State Refresh feature is an extension of the PIM Version 2 multicast routing architecture	“Configuring Basic IP Multicast” module
IP multicast commands: complete command syntax, command mode, defaults, command history, usage guidelines, and examples	<i>Cisco IOS IP Multicast Command Reference</i>

## Standards

Standard	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	--

## MIBs

MIB	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing standards has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

## RFCs

RFC	Title
No new or modified RFCs are supported by this feature, and support for existing standards has not been modified by this feature.	--

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/techsupport">http://www.cisco.com/techsupport</a>

## Feature History and Information for PIM Dense Mode State Refresh

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.



## CHAPTER 43

# IP Multicast Optimization: IGMP State Limit

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- [Prerequisites for IGMP State Limit, on page 713](#)
- [Restrictions for IGMP State Limit, on page 713](#)
- [Information About IGMP State Limit, on page 713](#)
- [How to Configure IGMP State Limit, on page 715](#)
- [Configuration examples for IGMP State Limit, on page 717](#)
- [Additional References, on page 718](#)
- [Feature History and Information for IGMP State Limit, on page 719](#)

## Prerequisites for IGMP State Limit

- IP multicast is enabled and the Protocol Independent Multicast (PIM) interfaces are configured using the tasks described in the "Configuring Basic IP Multicast" module of the *IP Multicast: PIM Configuration Guide*.
- ALL ACLs must be configured. For information, see the "Creating an IP Access List and Applying It to an Interface" module of the *Security Configuration Guide: Access Control Lists* guide.

## Restrictions for IGMP State Limit

You can configure only one global limit per device and one limit per interface.

## Information About IGMP State Limit

### IGMP State Limit

The IGMP State Limit feature allows for the configuration of IGMP state limiters, which impose limits on mroute states resulting from IGMP membership reports (IGMP joins) on a global or per interface basis. Membership reports exceeding the configured limits are not entered into the IGMP cache. This feature can be used to prevent DoS attacks or to provide a multicast CAC mechanism in network environments where all the multicast flows roughly utilize the same amount of bandwidth.




---

**Note** IGMP state limiters impose limits on the number of mroute states resulting from IGMP, IGMP v3lite, and URL Rendezvous Directory (URD) membership reports on a global or per interface basis.

---

## IGMP State Limit Feature Design

- Configuring IGMP state limiters in global configuration mode specifies a global limit on the number of IGMP membership reports that can be cached.
- Configuring IGMP state limiters in interface configuration mode specifies a limit on the number of IGMP membership reports on a per interface basis.
- Use ACLs to prevent groups or channels from being counted against the interface limit. A standard or an extended ACL can be specified. A standard ACL can be used to define the (\*, G) state to be excluded from the limit on an interface. An extended ACLs can be used to define the (S, G) state to be excluded from the limit on an interface. An extended ACL also can be used to define the (\*, G) state to be excluded from the limit on an interface, by specifying 0.0.0.0 for the source address and source wildcard--referred to as (0, G)--in the permit or deny statements that compose the extended access list.
- You can only configure one global limit per device and one limit per interface.

## Mechanics of IGMP State Limiters

The mechanics of IGMP state limiters are as follows:

- Each time a router receives an IGMP membership report for a particular group or channel, the Cisco IOS software checks to see if either the limit for the global IGMP state limiter or the limit for the per interface IGMP state limiter has been reached.
- If only a global IGMP state limiter has been configured and the limit has not been reached, IGMP membership reports are honored. When the configured limit has been reached, subsequent IGMP membership reports are then ignored (dropped) and a warning message in one of the following formats is generated:
  - ```
%IGMP-6-IGMP_GROUP_LIMIT: IGMP limit exceeded for <group (*, group address)> on <interface type number> by host <ip address>
```
  - ```
%IGMP-6-IGMP_CHANNEL_LIMIT: IGMP limit exceeded for <channel (source address, group address)> on <interface type number> by host <ip address>
```
- If only per interface IGMP state limiters are configured, then each limit is only counted against the interface on which it was configured.
- If both a global IGMP state limiter and per interface IGMP state limiters are configured, the limits configured for the per interface IGMP state limiters are still enforced but are constrained by the global limit.



# How to Configure IGMP State Limit

## Configuring IGMP State Limiters



**Note** IGMP state limiters impose limits on the number of mroute states resulting from IGMP, IGMP v3lite, and URD membership reports on a global or per interface basis.

### Configuring Global IGMP State Limiters

Perform this optional task to configure one global IGMP state limiter per device.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip igmp limit <i>number</i></b> <b>Example:</b>  Device(config)# ip igmp limit 150	Configures a global limit on the number of mroute states resulting from IGMP membership reports (IGMP joins).
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device(config-if)# end	Ends the current configuration session and returns to privileged EXEC mode.
<b>Step 5</b>	<b>show ip igmp groups</b> <b>Example:</b>  Device# show ip igmp groups	(Optional) Displays the multicast groups with receivers that are directly connected to the device and that were learned through IGMP.

### Configuring Per Interface IGMP State Limiters

Perform this optional task to configure a per interface IGMP state limiter.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>type number</i> <b>Example:</b> Device(config)# interface GigabitEthernet0/0	Enters interface configuration mode. <ul style="list-style-type: none"> <li>• Specify an interface that is connected to hosts.</li> </ul>
<b>Step 4</b>	<b>ip igmp limit</b> <i>number</i> [except <i>access-list</i> ] <b>Example:</b> Device(config-if)# ip igmp limit 100	Configures a per interface limit on the number of mroutes states created as a result of IGMP membership reports (IGMP joins).
<b>Step 5</b>	Do one of the following: <ul style="list-style-type: none"> <li>• exit</li> <li>• end</li> </ul> <b>Example:</b> Device(config-if)# exit Device(config-if)# end	<ul style="list-style-type: none"> <li>• (Optional) Ends the current configuration session and returns to global configuration mode. Repeat steps 3 and 4 to configure a per interface limiter on another interface.</li> <li>• Ends the current configuration session and returns to privileged EXEC mode.</li> </ul>
<b>Step 6</b>	<b>show ip igmp interface</b> [ <i>type number</i> ] <b>Example:</b> Device# show ip igmp interface	(Optional) Displays information about the status and configuration of IGMP and multicast routing on interfaces.
<b>Step 7</b>	<b>show ip igmp groups</b> <b>Example:</b> Device# show ip igmp groups	(Optional) Displays the multicast groups with receivers that are directly connected to the device and that were learned through IGMP.

# Configuration examples for IGMP State Limit

## Configuring IGMP State Limiters Example

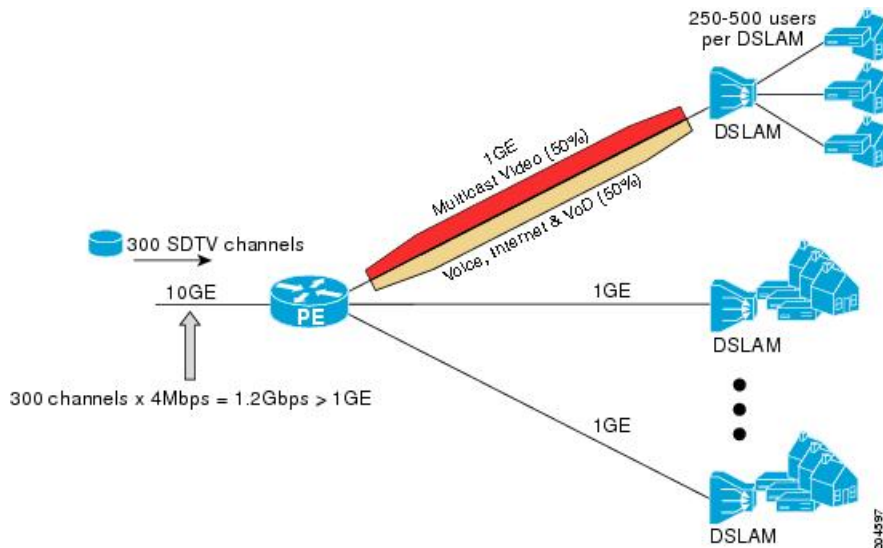
The following example shows how to configure IGMP state limiters to provide multicast CAC in a network environment where all the multicast flows roughly utilize the same amount of bandwidth.

This example uses the topology illustrated in the figure.



**Note** Although the following illustration and example uses routers in the configuration, any device (router or switch) can be used.

**Figure 43: IGMP State Limit Example Topology**



In this example, a service provider is offering 300 Standard Definition (SD) TV channels. Each SD channel utilizes approximately 4 Mbps.

The service provider must provision the Gigabit Ethernet interfaces on the PE router connected to the Digital Subscriber Line Access Multiplexers (DSLAMs) as follows: 50% of the link's bandwidth (500 Mbps) must be available to subscribers of the Internet, voice, and video on demand (VoD) service offerings while the remaining 50% (500 Mbps) of the link's bandwidth must be available to subscribers of the SD channel offerings.

Because each SD channel utilizes the same amount of bandwidth (4 Mbps), per interface IGMP state limiters can be used to provide the necessary CAC to provision the services being offered by the service provider. To determine the required CAC needed per interface, the total number of channels is divided by 4 (because each channel utilizes 4 Mbps of bandwidth). The required CAC needed per interface, therefore, is as follows:

$$500\text{Mbps} / 4\text{Mbps} = 125 \text{ mroutes}$$

Once the required CAC is determined, the service provider uses the results to configure the per IGMP state limiters required to provision the Gigabit Ethernet interfaces on the PE router. Based on the network's CAC

requirements, the service provider must limit the SD channels that can be transmitted out a Gigabit Ethernet interface (at any given time) to 125. Configuring a per interface IGMP state limit of 125 for the SD channels provisions the interface for 500 Mbps of bandwidth, the 50% of the link's bandwidth that must always be available (but never exceeded) for the SD channel offerings.

The following configuration shows how the service provider uses a per interface mroute state limiter to provision interface Gigabit Ethernet 0/0/0 for the SD channels and Internet, Voice, and VoD services being offered to subscribers:

```
interface GigabitEthernet0/0/0
description --- Interface towards the DSLAM ---
.
.
.
ip igmp limit 125
```

## Additional References

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
Cisco IOS IP Multicast commands	<a href="#">Cisco IOS IP Multicast Command Reference</a>

### MIBs

MIB	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing standards has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS XE releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

## Feature History and Information for IGMP State Limit

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.





# PART **VIII**

## **Layer 2/3**

- [Configuring Spanning Tree Protocol, on page 723](#)
- [Configuring Multiple Spanning-Tree Protocol, on page 749](#)
- [Configuring Optional Spanning-Tree Features, on page 781](#)
- [Configuring EtherChannels, on page 803](#)
- [Configuring Resilient Ethernet Protocol, on page 837](#)
- [Configuring UniDirectional Link Detection, on page 853](#)







## CHAPTER 44

# Configuring Spanning Tree Protocol

This chapter describes how to configure the Spanning Tree Protocol (STP) on port-based VLANs on the Catalyst devices. The device can use either the per-VLAN spanning-tree plus (PVST+) protocol based on the IEEE 802.1D standard and Cisco proprietary extensions, or the rapid per-VLAN spanning-tree plus (rapid-PVST+) protocol based on the IEEE 802.1w standard. A switch stack appears as a single spanning-tree node to the rest of the network, and all stack members use the same bridge ID.

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## Restrictions for STP

- An attempt to configure a device as the root device fails if the value necessary to be the root device is less than 1.
- If your network consists of devices that support and do not support the extended system ID, it is unlikely that the device with the extended system ID support will become the root device. The extended system ID increases the device priority value every time the VLAN number is greater than the priority of the connected devices running older software.
- The root device for each spanning-tree instance should be a backbone or distribution device. Do not configure an access device as the spanning-tree primary root.
- You cannot have a switch stack containing a mix of Catalyst 3850 and Catalyst 3650 switches.

## Information About Spanning Tree Protocol

### Spanning Tree Protocol

Spanning Tree Protocol (STP) is a Layer 2 link management protocol that provides path redundancy while preventing loops in the network. For a Layer 2 Ethernet network to function properly, only one active path

can exist between any two stations. Multiple active paths among end stations cause loops in the network. If a loop exists in the network, end stations might receive duplicate messages. Devices might also learn end-station MAC addresses on multiple Layer 2 interfaces. These conditions result in an unstable network. Spanning-tree operation is transparent to end stations, which cannot detect whether they are connected to a single LAN segment or a switched LAN of multiple segments.

The STP uses a spanning-tree algorithm to select one device of a redundantly connected network as the root of the spanning tree. The algorithm calculates the best loop-free path through a switched Layer 2 network by assigning a role to each port based on the role of the port in the active topology:

- Root—A forwarding port elected for the spanning-tree topology
- Designated—A forwarding port elected for every switched LAN segment
- Alternate—A blocked port providing an alternate path to the root bridge in the spanning tree
- Backup—A blocked port in a loopback configuration

The device that has *all* of its ports as the designated role or as the backup role is the root device. The device that has at least *one* of its ports in the designated role is called the designated device.

Spanning tree forces redundant data paths into a standby (blocked) state. If a network segment in the spanning tree fails and a redundant path exists, the spanning-tree algorithm recalculates the spanning-tree topology and activates the standby path. Devices send and receive spanning-tree frames, called bridge protocol data units (BPDUs), at regular intervals. The devices do not forward these frames but use them to construct a loop-free path. BPDUs contain information about the sending device and its ports, including device and MAC addresses, device priority, port priority, and path cost. Spanning tree uses this information to elect the root device and root port for the switched network and the root port and designated port for each switched segment.

When two ports on a device are part of a loop, the spanning-tree and path cost settings control which port is put in the forwarding state and which is put in the blocking state. The spanning-tree port priority value represents the location of a port in the network topology and how well it is located to pass traffic. The path cost value represents the media speed.




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**Note** By default, the device sends keepalive messages (to ensure the connection is up) only on interfaces that do not have small form-factor pluggable (SFP) modules. You can change the default for an interface by entering the **[no] keepalive** interface configuration command with no keywords.

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## Spanning-Tree Topology and BPDUs

The stable, active spanning-tree topology of a switched network is controlled by these elements:

- The unique bridge ID (device priority and MAC address) associated with each VLAN on each device. In a device stack, all devices use the same bridge ID for a given spanning-tree instance.
- The spanning-tree path cost to the root device.
- The port identifier (port priority and MAC address) associated with each Layer 2 interface.

When the devices in a network are powered up, each functions as the root device. Each device sends a configuration BPDU through all of its ports. The BPDUs communicate and compute the spanning-tree topology. Each configuration BPDU contains this information:

- The unique bridge ID of the device that the sending device identifies as the root device

- The spanning-tree path cost to the root
- The bridge ID of the sending device
- Message age
- The identifier of the sending interface
- Values for the hello, forward delay, and max-age protocol timers

When a device receives a configuration BPDU that contains *superior* information (lower bridge ID, lower path cost, and so forth), it stores the information for that port. If this BPDU is received on the root port of the device, the device also forwards it with an updated message to all attached LANs for which it is the designated device.

If a device receives a configuration BPDU that contains *inferior* information to that currently stored for that port, it discards the BPDU. If the device is a designated device for the LAN from which the inferior BPDU was received, it sends that LAN a BPDU containing the up-to-date information stored for that port. In this way, inferior information is discarded, and superior information is propagated on the network.

A BPDU exchange results in these actions:

- One device in the network is elected as the root device (the logical center of the spanning-tree topology in a switched network). See the figure following the bullets.

For each VLAN, the device with the highest device priority (the lowest numerical priority value) is elected as the root device. If all devices are configured with the default priority (32768), the device with the lowest MAC address in the VLAN becomes the root device. The device priority value occupies the most significant bits of the bridge ID, as shown in the following figure.

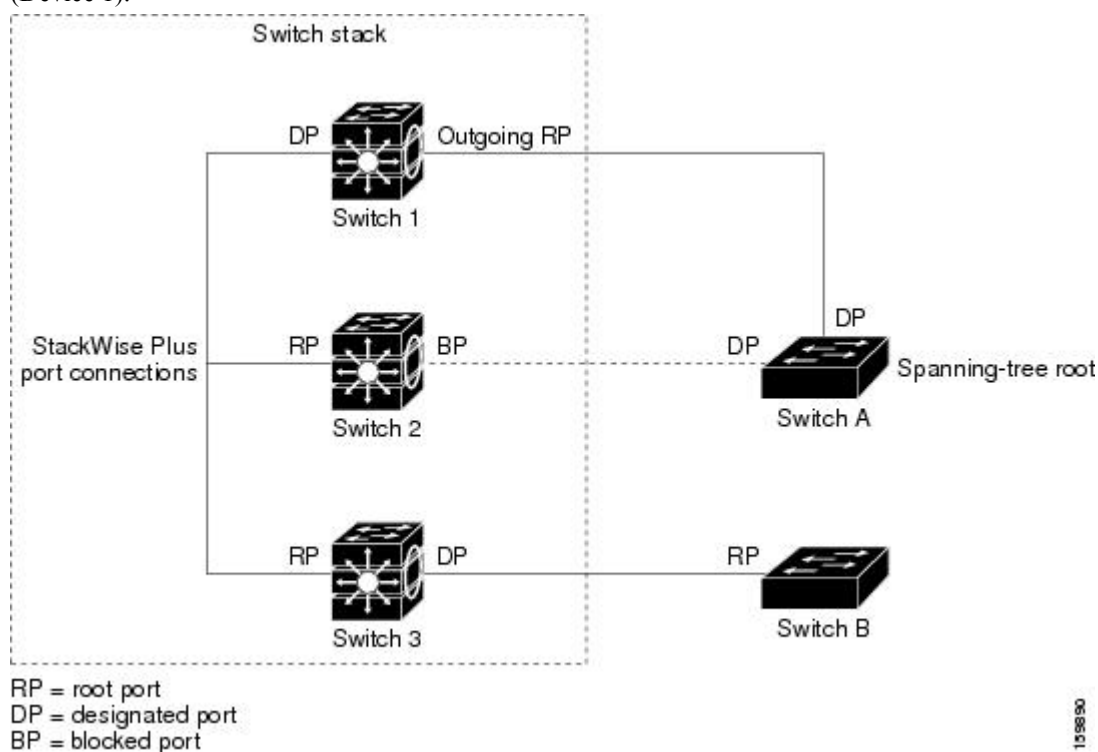
- A root port is selected for each device (except the root device). This port provides the best path (lowest cost) when the device forwards packets to the root device.

When selecting the root port on a device stack, spanning tree follows this sequence:

- Selects the lowest root bridge ID
  - Selects the lowest path cost to the root device
  - Selects the lowest designated bridge ID
  - Selects the lowest designated path cost
  - Selects the lowest port ID
- 
- Only one outgoing port on the stack root device is selected as the root port. The remaining devices in the stack become its designated devices (Device 2 and Device 3) as shown in the following figure.
  - The shortest distance to the root device is calculated for each device based on the path cost.
  - A designated device for each LAN segment is selected. The designated device incurs the lowest path cost when forwarding packets from that LAN to the root device. The port through which the designated device is attached to the LAN is called the designated port.

Figure 44: Spanning-Tree Port States in a Device Stack

One stack member is elected as the stack root device. The stack root device contains the outgoing root port (Device 1).



All paths that are not needed to reach the root device from anywhere in the switched network are placed in the spanning-tree blocking mode.

## Bridge ID, Device Priority, and Extended System ID

The IEEE 802.1D standard requires that each device has a unique bridge identifier (bridge ID), which controls the selection of the root device. Because each VLAN is considered as a different *logical bridge* with PVST+ and Rapid PVST+, the same device must have a different bridge ID for each configured VLAN. Each VLAN on the device has a unique 8-byte bridge ID. The 2 most-significant bytes are used for the device priority, and the remaining 6 bytes are derived from the device MAC address.

The device supports the IEEE 802.1t spanning-tree extensions, and some of the bits previously used for the device priority are now used as the VLAN identifier. The result is that fewer MAC addresses are reserved for the device, and a larger range of VLAN IDs can be supported, all while maintaining the uniqueness of the bridge ID.

The 2 bytes previously used for the device priority are reallocated into a 4-bit priority value and a 12-bit extended system ID value equal to the VLAN ID.

**Table 50: Device Priority Value and Extended System ID**

Priority Value				Extended System ID (Set Equal to the VLAN ID)											
Bit 16	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1
32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1

Spanning tree uses the extended system ID, the device priority, and the allocated spanning-tree MAC address to make the bridge ID unique for each VLAN. Because the device stack appears as a single device to the rest of the network, all devices in the stack use the same bridge ID for a given spanning tree. If the stack master fails, the stack members recalculate their bridge IDs of all running spanning trees based on the new MAC address of the new stack master.

Support for the extended system ID affects how you manually configure the root device, the secondary root device, and the device priority of a VLAN. For example, when you change the device priority value, you change the probability that the device will be elected as the root device. Configuring a higher value decreases the probability; a lower value increases the probability.

If any root device for the specified VLAN has a device priority lower than 24576, the device sets its own priority for the specified VLAN to 4096 less than the lowest device priority. 4096 is the value of the least-significant bit of a 4-bit device priority value as shown in the table.

## Port Priority Versus Path Cost

If a loop occurs, spanning tree uses port priority when selecting an interface to put into the forwarding state. You can assign higher priority values (lower numerical values) to interfaces that you want selected first and lower priority values (higher numerical values) that you want selected last. If all interfaces have the same priority value, spanning tree puts the interface with the lowest interface number in the forwarding state and blocks the other interfaces.

The spanning-tree path cost default value is derived from the media speed of an interface. If a loop occurs, spanning tree uses cost when selecting an interface to put in the forwarding state. You can assign lower cost values to interfaces that you want selected first and higher cost values that you want selected last. If all interfaces have the same cost value, spanning tree puts the interface with the lowest interface number in the forwarding state and blocks the other interfaces.

If your device is a member of a device stack, you must assign lower cost values to interfaces that you want selected first and higher cost values that you want selected last instead of adjusting its port priority. For details, see Related Topics.

## Spanning-Tree Interface States

Propagation delays can occur when protocol information passes through a switched LAN. As a result, topology changes can take place at different times and at different places in a switched network. When an interface transitions directly from nonparticipation in the spanning-tree topology to the forwarding state, it can create temporary data loops. Interfaces must wait for new topology information to propagate through the switched LAN before starting to forward frames. They must allow the frame lifetime to expire for forwarded frames that have used the old topology.

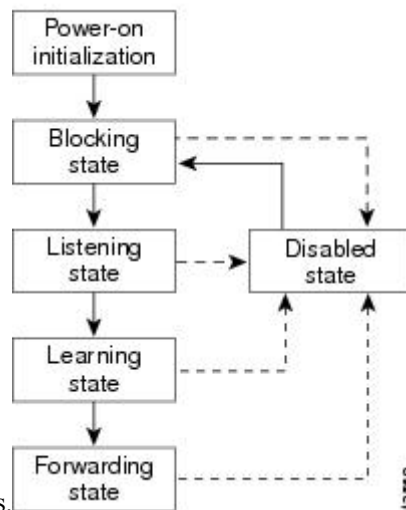
Each Layer 2 interface on a device using spanning tree exists in one of these states:

- Blocking—The interface does not participate in frame forwarding.
- Listening—The first transitional state after the blocking state when the spanning tree decides that the interface should participate in frame forwarding.
- Learning—The interface prepares to participate in frame forwarding.
- Forwarding—The interface forwards frames.
- Disabled—The interface is not participating in spanning tree because of a shutdown port, no link on the port, or no spanning-tree instance running on the port.

An interface moves through these states:

- From initialization to blocking
- From blocking to listening or to disabled
- From listening to learning or to disabled
- From learning to forwarding or to disabled
- From forwarding to disabled

**Figure 45: Spanning-Tree Interface States**



An interface moves through the states.

When you power up the device, spanning tree is enabled by default, and every interface in the device, VLAN, or network goes through the blocking state and the transitory states of listening and learning. Spanning tree stabilizes each interface at the forwarding or blocking state.

When the spanning-tree algorithm places a Layer 2 interface in the forwarding state, this process occurs:

1. The interface is in the listening state while spanning tree waits for protocol information to move the interface to the blocking state.
2. While spanning tree waits for the forward-delay timer to expire, it moves the interface to the learning state and resets the forward-delay timer.
3. In the learning state, the interface continues to block frame forwarding as the device learns end-station location information for the forwarding database.

4. When the forward-delay timer expires, spanning tree moves the interface to the forwarding state, where both learning and frame forwarding are enabled.

## Blocking State

A Layer 2 interface in the blocking state does not participate in frame forwarding. After initialization, a BPDU is sent to each device interface. A device initially functions as the root until it exchanges BPDUs with other devices. This exchange establishes which device in the network is the root or root device. If there is only one device in the network, no exchange occurs, the forward-delay timer expires, and the interface moves to the listening state. An interface always enters the blocking state after device initialization.

An interface in the blocking state performs these functions:

- Discards frames received on the interface
- Discards frames switched from another interface for forwarding
- Does not learn addresses
- Receives BPDUs

## Listening State

The listening state is the first state a Layer 2 interface enters after the blocking state. The interface enters this state when the spanning tree decides that the interface should participate in frame forwarding.

An interface in the listening state performs these functions:

- Discards frames received on the interface
- Discards frames switched from another interface for forwarding
- Does not learn addresses
- Receives BPDUs

## Learning State

A Layer 2 interface in the learning state prepares to participate in frame forwarding. The interface enters the learning state from the listening state.

An interface in the learning state performs these functions:

- Discards frames received on the interface
- Discards frames switched from another interface for forwarding
- Learns addresses
- Receives BPDUs

## Forwarding State

A Layer 2 interface in the forwarding state forwards frames. The interface enters the forwarding state from the learning state.

An interface in the forwarding state performs these functions:

- Receives and forwards frames received on the interface

- Forwards frames switched from another interface
- Learns addresses
- Receives BPDUs

## Disabled State

A Layer 2 interface in the disabled state does not participate in frame forwarding or in the spanning tree. An interface in the disabled state is nonoperational.

A disabled interface performs these functions:

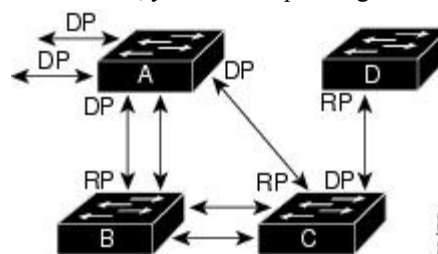
- Discards frames received on the interface
- Discards frames switched from another interface for forwarding
- Does not learn addresses
- Does not receive BPDUs

## How a Device or Port Becomes the Root Device or Root Port

If all devices in a network are enabled with default spanning-tree settings, the device with the lowest MAC address becomes the root device.

**Figure 46: Spanning-Tree Topology**

Device A is elected as the root device because the device priority of all the devices is set to the default (32768) and Device A has the lowest MAC address. However, because of traffic patterns, number of forwarding interfaces, or link types, Device A might not be the ideal root device. By increasing the priority (lowering the numerical value) of the ideal device so that it becomes the root device, you force a spanning-tree recalculation



RP = Root Port  
DP = Designated Port

to form a new topology with the ideal device as the root.

When the spanning-tree topology is calculated based on default parameters, the path between source and destination end stations in a switched network might not be ideal. For instance, connecting higher-speed links to an interface that has a higher number than the root port can cause a root-port change. The goal is to make the fastest link the root port.

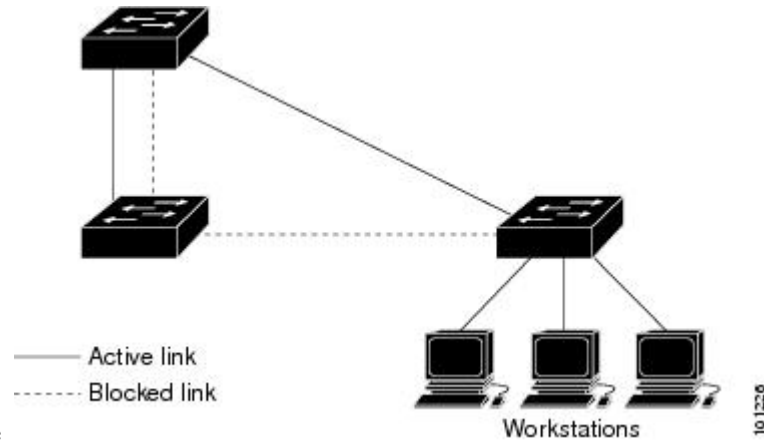
For example, assume that one port on Device B is a Gigabit Ethernet link and that another port on Device B (a 10/100 link) is the root port. Network traffic might be more efficient over the Gigabit Ethernet link. By changing the spanning-tree port priority on the Gigabit Ethernet port to a higher priority (lower numerical value) than the root port, the Gigabit Ethernet port becomes the new root port.



## Spanning Tree and Redundant Connectivity

Figure 47: Spanning Tree and Redundant Connectivity

You can create a redundant backbone with spanning tree by connecting two device interfaces to another device or to two different devices. Spanning tree automatically disables one interface but enables it if the other one fails. If one link is high-speed and the other is low-speed, the low-speed link is always disabled. If the speeds are the same, the port priority and port ID are added together, and spanning tree disables the link with the



highest value.

You can also create redundant links between devices by using EtherChannel groups.

## Spanning-Tree Address Management

IEEE 802.1D specifies 17 multicast addresses, ranging from 0x00180C2000000 to 0x0180C2000010, to be used by different bridge protocols. These addresses are static addresses that cannot be removed.

Regardless of the spanning-tree state, each device in the stack receives but does not forward packets destined for addresses between 0x0180C2000000 and 0x0180C200000F.

If spanning tree is enabled, the CPU on the device or on each device in the stack receives packets destined for 0x0180C2000000 and 0x0180C2000010. If spanning tree is disabled, the device or each device in the stack forwards those packets as unknown multicast addresses.

## Accelerated Aging to Retain Connectivity

The default for aging dynamic addresses is 5 minutes, the default setting of the **mac address-table aging-time** global configuration command. However, a spanning-tree reconfiguration can cause many station locations to change. Because these stations could be unreachable for 5 minutes or more during a reconfiguration, the address-aging time is accelerated so that station addresses can be dropped from the address table and then relearned. The accelerated aging is the same as the forward-delay parameter value (**spanning-tree vlan *vlan-id* forward-time *seconds*** global configuration command) when the spanning tree reconfigures.

Because each VLAN is a separate spanning-tree instance, the device accelerates aging on a per-VLAN basis. A spanning-tree reconfiguration on one VLAN can cause the dynamic addresses learned on that VLAN to be subject to accelerated aging. Dynamic addresses on other VLANs can be unaffected and remain subject to the aging interval entered for the device.

## Spanning-Tree Modes and Protocols

The device supports these spanning-tree modes and protocols:

- **PVST+**—This spanning-tree mode is based on the IEEE 802.1D standard and Cisco proprietary extensions. The PVST+ runs on each VLAN on the device up to the maximum supported, ensuring that each has a loop-free path through the network.

The PVST+ provides Layer 2 load-balancing for the VLAN on which it runs. You can create different logical topologies by using the VLANs on your network to ensure that all of your links are used but that no one link is oversubscribed. Each instance of PVST+ on a VLAN has a single root device. This root device propagates the spanning-tree information associated with that VLAN to all other devices in the network. Because each device has the same information about the network, this process ensures that the network topology is maintained.

- **Rapid PVST+**—Rapid PVST+ is the default STP mode on your device. This spanning-tree mode is the same as PVST+ except that it uses a rapid convergence based on the IEEE 802.1w standard. To provide rapid convergence, the Rapid PVST+ immediately deletes dynamically learned MAC address entries on a per-port basis upon receiving a topology change. By contrast, PVST+ uses a short aging time for dynamically learned MAC address entries.

Rapid PVST+ uses the same configuration as PVST+ (except where noted), and the device needs only minimal extra configuration. The benefit of Rapid PVST+ is that you can migrate a large PVST+ install base to Rapid PVST+ without having to learn the complexities of the Multiple Spanning Tree Protocol (MSTP) configuration and without having to re-provision your network. In Rapid PVST+ mode, each VLAN runs its own spanning-tree instance up to the maximum supported.

- **MSTP**—This spanning-tree mode is based on the IEEE 802.1s standard. You can map multiple VLANs to the same spanning-tree instance, which reduces the number of spanning-tree instances required to support a large number of VLANs. The MSTP runs on top of the RSTP (based on IEEE 802.1w), which provides for rapid convergence of the spanning tree by eliminating the forward delay and by quickly transitioning root ports and designated ports to the forwarding state. In a device stack, the cross-stack rapid transition (CSRT) feature performs the same function as RSTP. You cannot run MSTP without RSTP or CSRT.

## Supported Spanning-Tree Instances

In PVST+ or Rapid PVST+ mode, the device or device stack supports up to 128 spanning-tree instances.

In MSTP mode, the device or device stack supports up to 65 MST instances. The number of VLANs that can be mapped to a particular MST instance is unlimited.

## Spanning-Tree Interoperability and Backward Compatibility

In a mixed MSTP and PVST+ network, the common spanning-tree (CST) root must be inside the MST backbone, and a PVST+ device cannot connect to multiple MST regions.

When a network contains devices running Rapid PVST+ and devices running PVST+, we recommend that the Rapid PVST+ devices and PVST+ devices be configured for different spanning-tree instances. In the Rapid PVST+ spanning-tree instances, the root device must be a Rapid PVST+ device. In the PVST+ instances, the root device must be a PVST+ device. The PVST+ devices should be at the edge of the network.

All stack members run the same version of spanning tree (all PVST+, all Rapid PVST+, or all MSTP).

**Table 51: PVST+, MSTP, and Rapid-PVST+ Interoperability and Compatibility**

	<b>PVST+</b>	<b>MSTP</b>	<b>Rapid PVST+</b>
PVST+	Yes	Yes (with restrictions)	Yes (reverts to PVST+)

	PVST+	MSTP	Rapid PVST+
MSTP	Yes (with restrictions)	Yes	Yes (reverts to PVST+)
Rapid PVST+	Yes (reverts to PVST+)	Yes (reverts to PVST+)	Yes

## STP and IEEE 802.1Q Trunks

The IEEE 802.1Q standard for VLAN trunks imposes some limitations on the spanning-tree strategy for a network. The standard requires only one spanning-tree instance for *all* VLANs allowed on the trunks. However, in a network of Cisco devices connected through IEEE 802.1Q trunks, the devices maintain one spanning-tree instance for *each* VLAN allowed on the trunks.

When you connect a Cisco device to a non-Cisco device through an IEEE 802.1Q trunk, the Cisco device uses PVST+ to provide spanning-tree interoperability. If Rapid PVST+ is enabled, the device uses it instead of PVST+. The device combines the spanning-tree instance of the IEEE 802.1Q VLAN of the trunk with the spanning-tree instance of the non-Cisco IEEE 802.1Q device.

However, all PVST+ or Rapid PVST+ information is maintained by Cisco devices separated by a cloud of non-Cisco IEEE 802.1Q devices. The non-Cisco IEEE 802.1Q cloud separating the Cisco devices is treated as a single trunk link between the devices.

Rapid PVST+ is automatically enabled on IEEE 802.1Q trunks, and no user configuration is required. The external spanning-tree behavior on access ports and Inter-Switch Link (ISL) trunk ports is not affected by PVST+.

## Spanning Tree and Device Stacks

When the device stack is operating in PVST+ or Rapid PVST+ mode:

- A device stack appears as a single spanning-tree node to the rest of the network, and all stack members use the same bridge ID for a given spanning tree. The bridge ID is derived from the MAC address of the active switch.
- When a new device joins the stack, it sets its bridge ID to the active switch bridge ID. If the newly added device has the lowest ID and if the root path cost is the same among all stack members, the newly added device becomes the stack root.
- When a stack member leaves the stack, spanning-tree reconvergence occurs within the stack (and possibly outside the stack). The remaining stack member with the lowest stack port ID becomes the stack root.
- If the device stack is the spanning-tree root and the active switch fails or leaves the stack, the standby switch becomes the new active switch, bridge IDs remain the same, and a spanning-tree reconvergence might occur.
- If a neighboring device external to the device stack fails or is powered down, normal spanning-tree processing occurs. Spanning-tree reconvergence might occur as a result of losing a device in the active topology.
- If a new device external to the device stack is added to the network, normal spanning-tree processing occurs. Spanning-tree reconvergence might occur as a result of adding a device in the network.

## Default Spanning-Tree Configuration

Table 52: Default Spanning-Tree Configuration

Feature	Default Setting
Enable state	Enabled on VLAN 1.
Spanning-tree mode	Rapid PVST+ ( PVST+ and MSTP are disabled.)
Device priority	32768
Spanning-tree port priority (configurable on a per-interface basis)	128
Spanning-tree port cost (configurable on a per-interface basis)	1000 Mb/s: 4 100 Mb/s: 19 10 Mb/s: 100
Spanning-tree VLAN port priority (configurable on a per-VLAN basis)	128
Spanning-tree VLAN port cost (configurable on a per-VLAN basis)	1000 Mb/s: 4 100 Mb/s: 19 10 Mb/s: 100
Spanning-tree timers	Hello time: 2 seconds Forward-delay time: 15 seconds Maximum-aging time: 20 seconds Transmit hold count: 6 BPDUs



**Note** Beginning in Cisco IOS Release 15.2(4)E, the default STP mode is Rapid PVST+.

## How to Configure Spanning-Tree Features

### Changing the Spanning-Tree Mode (CLI)

The switch supports three spanning-tree modes: per-VLAN spanning tree plus (PVST+), Rapid PVST+, or multiple spanning tree protocol (MSTP). By default, the device runs the Rapid PVST+ protocol.

If you want to enable a mode that is different from the default mode, this procedure is required.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree mode {pvst   mst   rapid-pvst}</b> <b>Example:</b> <pre>Device(config)# spanning-tree mode pvst</pre>	Configures a spanning-tree mode. All stack members run the same version of spanning tree. <ul style="list-style-type: none"> <li>• Select <b>pvst</b> to enable PVST+.</li> <li>• Select <b>mst</b> to enable MSTP.</li> <li>• Select <b>rapid-pvst</b> to enable rapid PVST+.</li> </ul>
<b>Step 4</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> <pre>Device(config)# interface GigabitEthernet1/0/1</pre>	Specifies an interface to configure, and enters interface configuration mode. Valid interfaces include physical ports, VLANs, and port channels. The VLAN ID range is 1 to 4094. The port-channel range is 1 to 48.
<b>Step 5</b>	<b>spanning-tree link-type point-to-point</b> <b>Example:</b> <pre>Device(config-if)# spanning-tree link-type point-to-point</pre>	Specifies that the link type for this port is point-to-point. If you connect this port (local port) to a remote port through a point-to-point link and the local port becomes a designated port, the device negotiates with the remote port and rapidly changes the local port to the forwarding state.
<b>Step 6</b>	<b>end</b> <b>Example:</b> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>clear spanning-tree detected-protocols</b> <b>Example:</b> <pre>Device# clear spanning-tree detected-protocols</pre>	If any port on the device is connected to a port on a legacy IEEE 802.1D device, this command restarts the protocol migration process on the entire device. This step is optional if the designated device detects that this device is running rapid PVST+.

## Disabling Spanning Tree (CLI)

Spanning tree is enabled by default on VLAN 1 and on all newly created VLANs up to the spanning-tree limit. Disable spanning tree only if you are sure there are no loops in the network topology.



### Caution

When spanning tree is disabled and loops are present in the topology, excessive traffic and indefinite packet duplication can drastically reduce network performance.

This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>no spanning-tree vlan <i>vlan-id</i></b> <b>Example:</b> Device(config)# <b>no spanning-tree vlan 300</b>	For <i>vlan-id</i> , the range is 1 to 4094.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring the Root Device (CLI)

To configure a device as the root for the specified VLAN, use the **spanning-tree vlan *vlan-id* root** global configuration command to modify the device priority from the default value (32768) to a significantly lower value. When you enter this command, the software checks the device priority of the root devices for each VLAN. Because of the extended system ID support, the device sets its own priority for the specified VLAN to 24576 if this value will cause this device to become the root for the specified VLAN.

Use the **diameter** keyword to specify the Layer 2 network diameter (that is, the maximum number of device hops between any two end stations in the Layer 2 network). When you specify the network diameter, the device automatically sets an optimal hello time, forward-delay time, and maximum-age time for a network

of that diameter, which can significantly reduce the convergence time. You can use the **hello** keyword to override the automatically calculated hello time.

This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree vlan <i>vlan-id</i> root primary</b> <b>[diameter <i>net-diameter</i></b> <b>Example:</b> Device(config)# <b>spanning-tree vlan 20-24</b> <b>root primary diameter 4</b>	Configures a device to become the root for the specified VLAN. <ul style="list-style-type: none"> <li>• For <i>vlan-id</i>, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094.</li> <li>• (Optional) For <b>diameter <i>net-diameter</i></b>, specify the maximum number of devices between any two end stations. The range is 2 to 7.</li> </ul>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

### What to do next

After configuring the device as the root device, we recommend that you avoid manually configuring the hello time, forward-delay time, and maximum-age time through the **spanning-tree vlan *vlan-id* hello-time**, **spanning-tree vlan *vlan-id* forward-time**, and the **spanning-tree vlan *vlan-id* max-age** global configuration commands.

## Configuring a Secondary Root Device (CLI)

When you configure a device as the secondary root, the device priority is modified from the default value (32768) to 28672. With this priority, the device is likely to become the root device for the specified VLAN

if the primary root device fails. This is assuming that the other network devices use the default device priority of 32768, and therefore, are unlikely to become the root device.

You can execute this command on more than one device to configure multiple backup root devices. Use the same network diameter and hello-time values that you used when you configured the primary root device with the **spanning-tree vlan *vlan-id* root primary** global configuration command.

This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree vlan <i>vlan-id</i> root secondary</b> <b>[diameter <i>net-diameter</i></b> <b>Example:</b> Device(config)# <b>spanning-tree vlan 20-24</b> <b>root secondary diameter 4</b>	Configures a device to become the secondary root for the specified VLAN. <ul style="list-style-type: none"> <li>• For <i>vlan-id</i>, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094.</li> <li>• (Optional) For <b>diameter <i>net-diameter</i></b>, specify the maximum number of devices between any two end stations. The range is 2 to 7.</li> </ul> Use the same network diameter value that you used when configuring the primary root device.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.



## Configuring Port Priority (CLI)



**Note** If your device is a member of a device stack, you must use the **spanning-tree [vlan *vlan-id*] cost *cost*** interface configuration command instead of the **spanning-tree [vlan *vlan-id*] port-priority *priority*** interface configuration command to select an interface to put in the forwarding state. Assign lower cost values to interfaces that you want selected first and higher cost values that you want selected last.

This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/2</b>	Specifies an interface to configure, and enters interface configuration mode.  Valid interfaces include physical ports and port-channel logical interfaces ( <b>port-channel <i>port-channel-number</i></b> ).
<b>Step 4</b>	<b>spanning-tree port-priority <i>priority</i></b> <b>Example:</b> Device(config-if)# <b>spanning-tree port-priority 0</b>	Configures the port priority for an interface.  For <i>priority</i> , the range is 0 to 240, in increments of 16; the default is 128. Valid values are 0, 16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, and 240. All other values are rejected. The lower the number, the higher the priority.
<b>Step 5</b>	<b>spanning-tree vlan <i>vlan-id</i> port-priority <i>priority</i></b> <b>Example:</b> Device(config-if)# <b>spanning-tree vlan 20-25 port-priority 0</b>	Configures the port priority for a VLAN. <ul style="list-style-type: none"> <li>• For <i>vlan-id</i>, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094.</li> <li>• For <i>priority</i>, the range is 0 to 240, in increments of 16; the default is 128. Valid values are 0, 16, 32, 48, 64, 80, 96, 112,</li> </ul>

	Command or Action	Purpose
		128, 144, 160, 176, 192, 208, 224, and 240. All other values are rejected. The lower the number, the higher the priority.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config-if) # <b>end</b>	Returns to privileged EXEC mode.

## Configuring Path Cost (CLI)

This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/1</b>	Specifies an interface to configure, and enters interface configuration mode. Valid interfaces include physical ports and port-channel logical interfaces ( <b>port-channel <i>port-channel-number</i></b> ).
<b>Step 4</b>	<b>spanning-tree cost <i>cost</i></b> <b>Example:</b> Device(config-if) # <b>spanning-tree cost 250</b>	Configures the cost for an interface.  If a loop occurs, spanning tree uses the path cost when selecting an interface to place into the forwarding state. A lower path cost represents higher-speed transmission.  For <i>cost</i> , the range is 1 to 200000000; the default value is derived from the media speed of the interface.
<b>Step 5</b>	<b>spanning-tree vlan <i>vlan-id</i> cost <i>cost</i></b> <b>Example:</b>	Configures the cost for a VLAN.  If a loop occurs, spanning tree uses the path cost when selecting an interface to place into the

	Command or Action	Purpose
	<pre>Device(config-if)# spanning-tree vlan 10,12-15,20 cost 300</pre>	<p>forwarding state. A lower path cost represents higher-speed transmission.</p> <ul style="list-style-type: none"> <li>For <i>vlan-id</i>, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094.</li> <li>For <i>cost</i>, the range is 1 to 200000000; the default value is derived from the media speed of the interface.</li> </ul>
<b>Step 6</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.

The **show spanning-tree interface *interface-id*** privileged EXEC command displays information only for ports that are in a link-up operative state. Otherwise, you can use the **show running-config** privileged EXEC command to confirm the configuration.

## Configuring the Device Priority of a VLAN (CLI)

You can configure the device priority and make it more likely that a standalone device or a device in the stack will be chosen as the root device.



**Note** Exercise care when using this command. For most situations, we recommend that you use the **spanning-tree vlan *vlan-id* root primary** and the **spanning-tree vlan *vlan-id* root secondary** global configuration commands to modify the device priority.

This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 3</b>	<b>spanning-tree vlan <i>vlan-id</i> priority <i>priority</i></b> <b>Example:</b> Device(config)# <code>spanning-tree vlan 20 priority 8192</code>	Configures the device priority of a VLAN. <ul style="list-style-type: none"> <li>For <i>vlan-id</i>, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094.</li> <li>For <i>priority</i>, the range is 0 to 61440 in increments of 4096; the default is 32768. The lower the number, the more likely the device will be chosen as the root device.</li> </ul> Valid priority values are 4096, 8192, 12288, 16384, 20480, 24576, 28672, 32768, 36864, 40960, 45056, 49152, 53248, 57344, and 61440. All other values are rejected.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config-if)# <code>end</code>	Returns to privileged EXEC mode.

## Configuring the Hello Time (CLI)

The hello time is the time interval between configuration messages generated and sent by the root device. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>spanning-tree vlan <i>vlan-id</i> hello-time <i>seconds</i></b> <b>Example:</b> Device(config)# <code>spanning-tree vlan 20-24 hello-time 3</code>	Configures the hello time of a VLAN. The hello time is the time interval between configuration messages generated and sent by the root device. These messages mean that the device is alive. <ul style="list-style-type: none"> <li>For <i>vlan-id</i>, you can specify a single VLAN identified by VLAN ID number, a</li> </ul>

	Command or Action	Purpose
		<p>range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094.</p> <ul style="list-style-type: none"> <li>• For <i>seconds</i>, the range is 1 to 10; the default is 2.</li> </ul>
<b>Step 3</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.

## Configuring the Forwarding-Delay Time for a VLAN (CLI)

This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<p><b>spanning-tree vlan <i>vlan-id</i> forward-time <i>seconds</i></b></p> <p><b>Example:</b></p> <pre>Device(config)# spanning-tree vlan 20,25 forward-time 18</pre>	<p>Configures the forward time of a VLAN. The forwarding delay is the number of seconds an interface waits before changing from its spanning-tree learning and listening states to the forwarding state.</p> <ul style="list-style-type: none"> <li>• For <i>vlan-id</i>, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094.</li> <li>• For <i>seconds</i>, the range is 4 to 30; the default is 15.</li> </ul>
<b>Step 4</b>	<p><b>end</b></p> <p><b>Example:</b></p>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	Device(config)# <b>end</b>	

## Configuring the Maximum-Aging Time for a VLAN (CLI)

This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree vlan <i>vlan-id</i> max-age <i>seconds</i></b> <b>Example:</b> Device(config)# <b>spanning-tree vlan 20 max-age 30</b>	Configures the maximum-aging time of a VLAN. The maximum-aging time is the number of seconds a device waits without receiving spanning-tree configuration messages before attempting a reconfiguration. <ul style="list-style-type: none"> <li>• For <i>vlan-id</i>, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094.</li> <li>• For <i>seconds</i>, the range is 6 to 40; the default is 20.</li> </ul>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring the Transmit Hold-Count (CLI)

You can configure the BPDU burst size by changing the transmit hold count value.



**Note** Changing this parameter to a higher value can have a significant impact on CPU utilization, especially in Rapid PVST+ mode. Lowering this value can slow down convergence in certain scenarios. We recommend that you maintain the default setting.

This procedure is optional.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree transmit hold-count <i>value</i></b> <b>Example:</b> Device(config)# <b>spanning-tree transmit hold-count 6</b>	Configures the number of BPDUs that can be sent before pausing for 1 second. For <i>value</i> , the range is 1 to 20; the default is 6.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Monitoring Spanning-Tree Status

*Table 53: Commands for Displaying Spanning-Tree Status*

<b>show spanning-tree active</b>	Displays spanning-tree information on active interfaces only.
<b>show spanning-tree detail</b>	Displays a detailed summary of interface information.
<b>show spanning-tree vlan <i>vlan-id</i></b>	Displays spanning-tree information for the specified VLAN.

<b>show spanning-tree interface</b> <i>interface-id</i>	Displays spanning-tree information for the specified interface.
<b>show spanning-tree interface</b> <i>interface-id</i> <b>portfast</b>	Displays spanning-tree portfast information for the specified interface.
<b>show spanning-tree summary</b> [ <b>totals</b> ]	Displays a summary of interface states or displays the total lines of the STP state section.

To clear spanning-tree counters, use the **clear spanning-tree** [**interface** *interface-id*] privileged EXEC command.

## Additional References for Spanning-Tree Protocol

### Related Documents

Related Topic	Document Title
Spanning tree protocol commands	<i>LAN Switching Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>

### Standards and RFCs

Standard/RFC	Title
None	—

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>



**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

**Feature Information for STP**

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.





## CHAPTER 45

# Configuring Multiple Spanning-Tree Protocol

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- [Restrictions for MSTP, on page 749](#)
- [Information About MSTP, on page 750](#)
- [How to Configure MSTP Features, on page 765](#)
- [Additional References for MSTP, on page 779](#)
- [Feature Information for MSTP, on page 779](#)

## Prerequisites for MSTP

- For two or more devices to be in the same multiple spanning tree (MST) region, they must have the same VLAN-to-instance map, the same configuration revision number, and the same name.
- For two or more stacked switches to be in the same MST region, they must have the same VLAN-to-instance map, the same configuration revision number, and the same name.
- For load-balancing across redundant paths in the network to work, all VLAN-to-instance mapping assignments must match; otherwise, all traffic flows on a single link. You can achieve load-balancing across a device stack by manually configuring the path cost.
- For load-balancing between a per-VLAN spanning tree plus (PVST+) and an MST cloud or between a rapid-PVST+ and an MST cloud to work, all MST boundary ports must be forwarding. MST boundary ports are forwarding when the internal spanning tree (IST) master of the MST cloud is the root of the common spanning tree (CST). If the MST cloud consists of multiple MST regions, one of the MST regions must contain the CST root, and all of the other MST regions must have a better path to the root contained within the MST cloud than a path through the PVST+ or rapid-PVST+ cloud. You might have to manually configure the devices in the clouds.

## Restrictions for MSTP

- You cannot have a switch stack containing a mix of Catalyst 3850 and Catalyst 3650 switches.
- The device stack supports up to 65 MST instances. The number of VLANs that can be mapped to a particular MST instance is unlimited.
- PVST+, Rapid PVST+, and MSTP are supported, but only one version can be active at any time. (For example, all VLANs run PVST+, all VLANs run Rapid PVST+, or all VLANs run MSTP.)

- All stack members must run the same version of spanning tree (all PVST+, Rapid PVST+, or MSTP).
- VLAN Trunking Protocol (VTP) propagation of the MST configuration is not supported. However, you can manually configure the MST configuration (region name, revision number, and VLAN-to-instance mapping) on each device within the MST region by using the command-line interface (CLI) or through the Simple Network Management Protocol (SNMP) support.
- Partitioning the network into a large number of regions is not recommended. However, if this situation is unavoidable, we recommend that you partition the switched LAN into smaller LANs interconnected by routers or non-Layer 2 devices.
- A region can have one member or multiple members with the same MST configuration; each member must be capable of processing rapid spanning tree protocol (RSTP) Bridge Protocol Data Units (BPDUs). There is no limit to the number of MST regions in a network, but each region can only support up to 65 spanning-tree instances. You can assign a VLAN to only one spanning-tree instance at a time.
- After configuring a device as the root device, we recommend that you avoid manually configuring the hello time, forward-delay time, and maximum-age time through the **spanning-tree mst hello-time**, **spanning-tree mst forward-time**, and the **spanning-tree mst max-age** global configuration commands.

*Table 54: PVST+, MSTP, and Rapid PVST+ Interoperability and Compatibility*

	PVST+	MSTP	Rapid PVST+
PVST+	Yes	Yes (with restrictions)	Yes (reverts to PVST+)
MSTP	Yes (with restrictions)	Yes	Yes (reverts to PVST+)
Rapid PVST+	Yes (reverts to PVST+)	Yes (reverts to PVST+)	Yes

## Information About MSTP

### MSTP Configuration

MSTP, which uses RSTP for rapid convergence, enables multiple VLANs to be grouped into and mapped to the same spanning-tree instance, reducing the number of spanning-tree instances needed to support a large number of VLANs. The MSTP provides for multiple forwarding paths for data traffic, enables load balancing, and reduces the number of spanning-tree instances required to support a large number of VLANs. It improves the fault tolerance of the network because a failure in one instance (forwarding path) does not affect other instances (forwarding paths).



**Note** The multiple spanning-tree (MST) implementation is based on the IEEE 802.1s standard.

The most common initial deployment of MSTP is in the backbone and distribution layers of a Layer 2 switched network. This deployment provides the highly available network required in a service-provider environment.

When the device is in the MST mode, the RSTP, which is based on IEEE 802.1w, is automatically enabled. The RSTP provides rapid convergence of the spanning tree through explicit handshaking that eliminates the IEEE 802.1D forwarding delay and quickly transitions root ports and designated ports to the forwarding state.

Both MSTP and RSTP improve the spanning-tree operation and maintain backward compatibility with equipment that is based on the (original) IEEE 802.1D spanning tree, with existing Cisco-proprietary Multiple Instance STP (MISTP), and with existing Cisco PVST+ and rapid per-VLAN spanning-tree plus (Rapid PVST+).

A device stack appears as a single spanning-tree node to the rest of the network, and all stack members use the same device ID.

## MSTP Configuration Guidelines

- When you enable MST by using the **spanning-tree mode mst** global configuration command, RSTP is automatically enabled.
- For configuration guidelines about UplinkFast, BackboneFast, and cross-stack UplinkFast, see the relevant sections in the Related Topics section.
- When the device is in MST mode, it uses the long path-cost calculation method (32 bits) to compute the path cost values. With the long path-cost calculation method, the following path cost values are supported:

Speed	Path Cost Value
10 Mb/s	2,000,000
100 Mb/s	200,000
1 Gb/s	20,000
10 Gb/s	2,000
100 Gb/s	200

## Root Switch

The device maintains a spanning-tree instance for the group of VLANs mapped to it. A device ID, consisting of the device priority and the device MAC address, is associated with each instance. For a group of VLANs, the device with the lowest device ID becomes the root device.

When you configure a device as the root, you modify the device priority from the default value (32768) to a significantly lower value so that the device becomes the root device for the specified spanning-tree instance. When you enter this command, the device checks the device priorities of the root devices. Because of the extended system ID support, the device sets its own priority for the specified instance to 24576 if this value will cause this devices to become the root for the specified spanning-tree instance.

If any root device for the specified instance has a device priority lower than 24576, the device sets its own priority to 4096 less than the lowest device priority. (4096 is the value of the least-significant bit of a 4-bit device priority value. For more information, select "Bridge ID, Device Priority, and Extended System ID" link in Related Topics.

If your network consists of devices that support and do not support the extended system ID, it is unlikely that the device with the extended system ID support will become the root device. The extended system ID increases the device priority value every time the VLAN number is greater than the priority of the connected switches running older software.

The root device for each spanning-tree instance should be a backbone or distribution device. Do not configure an access device as the spanning-tree primary root.

Use the **diameter** keyword, which is available only for MST instance 0, to specify the Layer 2 network diameter (that is, the maximum number of device hops between any two end stations in the Layer 2 network). When you specify the network diameter, the device automatically sets an optimal hello time, forward-delay time, and maximum-age time for a network of that diameter, which can significantly reduce the convergence time. You can use the **hello** keyword to override the automatically calculated hello time.

## Multiple Spanning-Tree Regions

For switches to participate in multiple spanning-tree (MST) instances, you must consistently configure the switches with the same MST configuration information. A collection of interconnected switches that have the same MST configuration comprises an MST region.

The MST configuration controls to which MST region each device belongs. The configuration includes the name of the region, the revision number, and the MST VLAN-to-instance assignment map. You configure the device for a region by specifying the MST region configuration on it. You can map VLANs to an MST instance, specify the region name, and set the revision number. For instructions and an example, select the "Specifying the MST Region Configuration and Enabling MSTP" link in Related Topics.

A region can have one or multiple members with the same MST configuration. Each member must be capable of processing RSTP bridge protocol data units (BPDUs). There is no limit to the number of MST regions in a network, but each region can support up to 65 spanning-tree instances. Instances can be identified by any number in the range from 0 to 4094. You can assign a VLAN to only one spanning-tree instance at a time.

## IST, CIST, and CST

Unlike PVST+ and Rapid PVST+ in which all the spanning-tree instances are independent, the MSTP establishes and maintains two types of spanning trees:

- An internal spanning tree (IST), which is the spanning tree that runs in an MST region.

Within each MST region, the MSTP maintains multiple spanning-tree instances. Instance 0 is a special instance for a region, known as the internal spanning tree (IST). All other MST instances are numbered from 1 to 4094.

The IST is the only spanning-tree instance that sends and receives BPDUs. All of the other spanning-tree instance information is contained in M-records, which are encapsulated within MSTP BPDUs. Because the MSTP BPDU carries information for all instances, the number of BPDUs that need to be processed to support multiple spanning-tree instances is significantly reduced.

All MST instances within the same region share the same protocol timers, but each MST instance has its own topology parameters, such as root device ID, root path cost, and so forth. By default, all VLANs are assigned to the IST.

An MST instance is local to the region; for example, MST instance 1 in region A is independent of MST instance 1 in region B, even if regions A and B are interconnected.

- A common and internal spanning tree (CIST), which is a collection of the ISTs in each MST region, and the common spanning tree (CST) that interconnects the MST regions and single spanning trees.

The spanning tree computed in a region appears as a subtree in the CST that encompasses the entire switched domain. The CIST is formed by the spanning-tree algorithm running among switches that

support the IEEE 802.1w, IEEE 802.1s, and IEEE 802.1D standards. The CIST inside an MST region is the same as the CST outside a region.

## Operations Within an MST Region

The IST connects all the MSTP switches in a region. When the IST converges, the root of the IST becomes the CIST regional root (called the *IST master* before the implementation of the IEEE 802.1s standard). It is the device within the region with the lowest device ID and path cost to the CIST root. The CIST regional root is also the CIST root if there is only one region in the network. If the CIST root is outside the region, one of the MSTP switches at the boundary of the region is selected as the CIST regional root.

When an MSTP device initializes, it sends BPDUs claiming itself as the root of the CIST and the CIST regional root, with both of the path costs to the CIST root and to the CIST regional root set to zero. The device also initializes all of its MST instances and claims to be the root for all of them. If the device receives superior MST root information (lower device ID, lower path cost, and so forth) than currently stored for the port, it relinquishes its claim as the CIST regional root.

During initialization, a region might have many subregions, each with its own CIST regional root. As switches receive superior IST information, they leave their old subregions and join the new subregion that contains the true CIST regional root. All subregions shrink except for the one that contains the true CIST regional root.

For correct operation, all switches in the MST region must agree on the same CIST regional root. Therefore, any two switches in the region only synchronize their port roles for an MST instance if they converge to a common CIST regional root.

## Operations Between MST Regions

If there are multiple regions or legacy IEEE 802.1D devices within the network, MSTP establishes and maintains the CST, which includes all MST regions and all legacy STP devices in the network. The MST instances combine with the IST at the boundary of the region to become the CST.

The IST connects all the MSTP devices in the region and appears as a subtree in the CIST that encompasses the entire switched domain. The root of the subtree is the CIST regional root. The MST region appears as a virtual device to adjacent STP devices and MST regions.

Only the CST instance sends and receives BPDUs, and MST instances add their spanning-tree information into the BPDUs to interact with neighboring devices and compute the final spanning-tree topology. Because of this, the spanning-tree parameters related to BPDU transmission (for example, hello time, forward time, max-age, and max-hops) are configured only on the CST instance but affect all MST instances. Parameters related to the spanning-tree topology (for example, device priority, port VLAN cost, and port VLAN priority) can be configured on both the CST instance and the MST instance.

MSTP devices use Version 3 RSTP BPDUs or IEEE 802.1D STP BPDUs to communicate with legacy IEEE 802.1D devices. MSTP devices use MSTP BPDUs to communicate with MSTP devices.

## IEEE 802.1s Terminology

Some MST naming conventions used in Cisco's prestandard implementation have been changed to identify some *internal* or *regional* parameters. These parameters are significant only within an MST region, as opposed to external parameters that are relevant to the whole network. Because the CIST is the only spanning-tree instance that spans the whole network, only the CIST parameters require the external rather than the internal or regional qualifiers.

- The CIST root is the root device for the unique instance that spans the whole network, the CIST.

- The CIST external root path cost is the cost to the CIST root. This cost is left unchanged within an MST region. Remember that an MST region looks like a single device for the CIST. The CIST external root path cost is the root path cost calculated between these virtual devices and devices that do not belong to any region.
- The CIST regional root was called the IST master in the prestandard implementation. If the CIST root is in the region, the CIST regional root is the CIST root. Otherwise, the CIST regional root is the closest device to the CIST root in the region. The CIST regional root acts as a root device for the IST.
- The CIST internal root path cost is the cost to the CIST regional root in a region. This cost is only relevant to the IST, instance 0.

**Table 55: Prestandard and Standard Terminology**

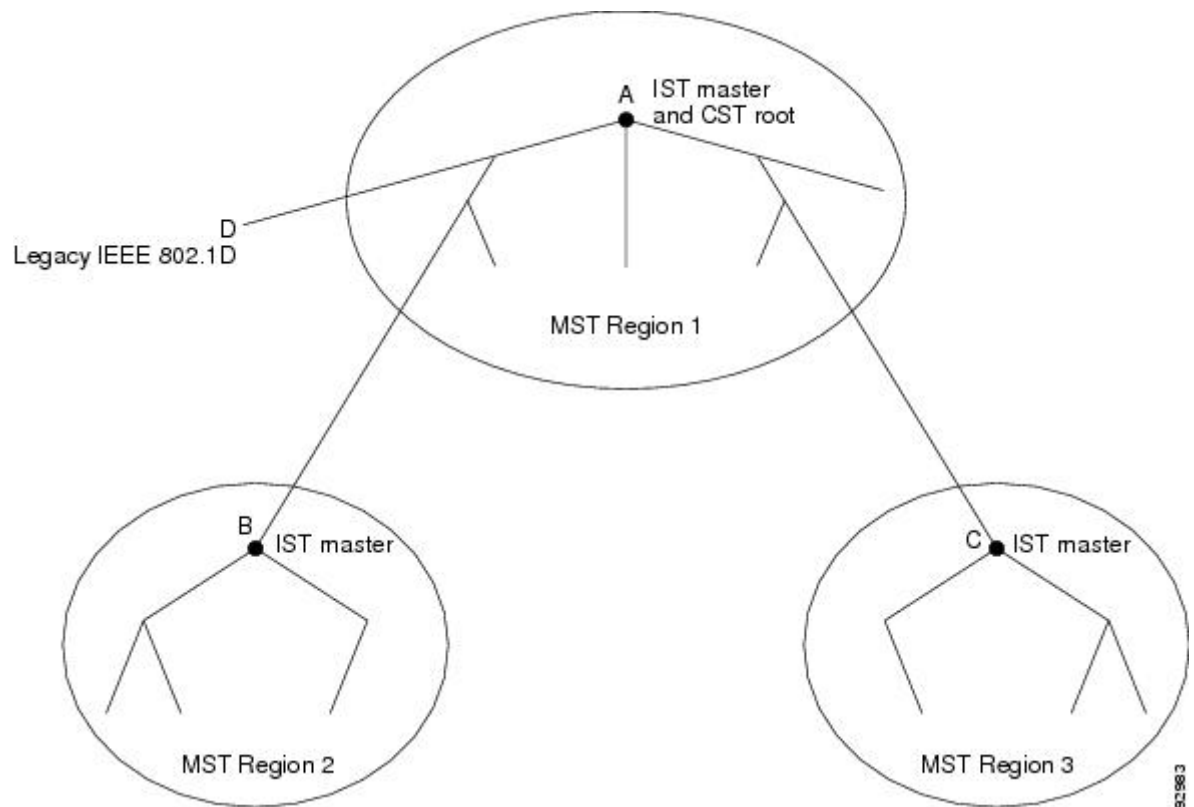
IEEE Standard	Cisco Prestandard	Cisco Standard
CIST regional root	IST master	CIST regional root
CIST internal root path cost	IST master path cost	CIST internal path cost
CIST external root path cost	Root path cost	Root path cost
MSTI regional root	Instance root	Instance root
MSTI internal root path cost	Root path cost	Root path cost

## Illustration of MST Regions

This figure displays three MST regions and a legacy IEEE 802.1D device (D). The CIST regional root for region 1 (A) is also the CIST root. The CIST regional root for region 2 (B) and the CIST regional root for region 3 (C) are the roots for their respective subtrees within the CIST. The RSTP runs in all regions.



Figure 48: MST Regions, CIST Masters, and CST Root



## Hop Count

The IST and MST instances do not use the message-age and maximum-age information in the configuration BPDU to compute the spanning-tree topology. Instead, they use the path cost to the root and a hop-count mechanism similar to the IP time-to-live (TTL) mechanism.

By using the **spanning-tree mst max-hops** global configuration command, you can configure the maximum hops inside the region and apply it to the IST and all MST instances in that region. The hop count achieves the same result as the message-age information (triggers a reconfiguration). The root device of the instance always sends a BPDU (or M-record) with a cost of 0 and the hop count set to the maximum value. When a device receives this BPDU, it decrements the received remaining hop count by one and propagates this value as the remaining hop count in the BPDUs it generates. When the count reaches zero, the device discards the BPDU and ages the information held for the port.

The message-age and maximum-age information in the RSTP portion of the BPDU remain the same throughout the region, and the same values are propagated by the region designated ports at the boundary.

## Boundary Ports

In the Cisco prestandard implementation, a boundary port connects an MST region to a single spanning-tree region running RSTP, to a single spanning-tree region running PVST+ or rapid PVST+, or to another MST region with a different MST configuration. A boundary port also connects to a LAN, the designated device of which is either a single spanning-tree device or a device with a different MST configuration.

There is no definition of a boundary port in the IEEE 802.1s standard. The IEEE 802.1Q-2002 standard identifies two kinds of messages that a port can receive:

- internal (coming from the same region)
- external (coming from another region)

When a message is internal, the CIST part is received by the CIST, and each MST instance receives its respective M-record.

When a message is external, it is received only by the CIST. If the CIST role is root or alternate, or if the external BPDU is a topology change, it could have an impact on the MST instances.

An MST region includes both devices and LANs. A segment belongs to the region of its designated port. Therefore, a port in a different region than the designated port for a segment is a boundary port. This definition allows two ports internal to a region to share a segment with a port belonging to a different region, creating the possibility of a port receiving both internal and external messages.

The primary change from the Cisco prestandard implementation is that a designated port is not defined as boundary, unless it is running in an STP-compatible mode.




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**Note** If there is a legacy STP device on the segment, messages are always considered external.

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The other change from the Cisco prestandard implementation is that the CIST regional root device ID field is now inserted where an RSTP or legacy IEEE 802.1Q device has the sender device ID. The whole region performs like a single virtual device by sending a consistent sender device ID to neighboring devices. In this example, device C would receive a BPDU with the same consistent sender device ID of root, whether or not A or B is designated for the segment.

## IEEE 802.1s Implementation

The Cisco implementation of the IEEE MST standard includes features required to meet the standard, as well as some of the desirable prestandard functionality that is not yet incorporated into the published standard.

### Port Role Naming Change

The boundary role is no longer in the final MST standard, but this boundary concept is maintained in Cisco's implementation. However, an MST instance port at a boundary of the region might not follow the state of the corresponding CIST port. Two boundary roles currently exist:

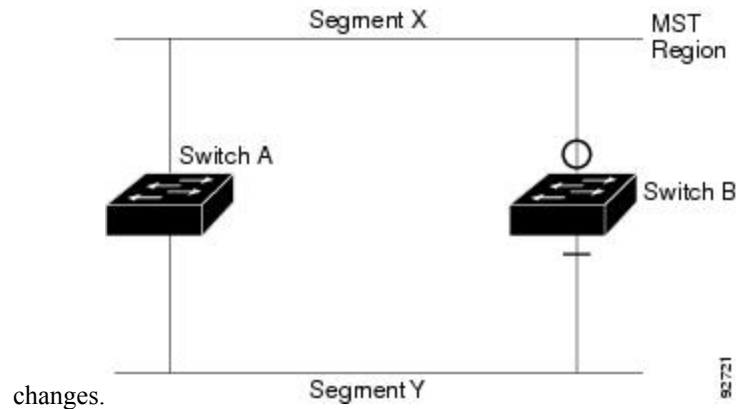
- The boundary port is the root port of the CIST regional root—When the CIST instance port is proposed and is in sync, it can send back an agreement and move to the forwarding state only after all the corresponding MSTI ports are in sync (and thus forwarding). The MSTI ports now have a special *master* role.
- The boundary port is not the root port of the CIST regional root—The MSTI ports follow the state and role of the CIST port. The standard provides less information, and it might be difficult to understand why an MSTI port can be alternately blocking when it receives no BPDUs (MRecords). In this case, although the boundary role no longer exists, the **show** commands identify a port as boundary in the *type* column of the output.

## Interoperation Between Legacy and Standard Devices

Because automatic detection of prestandard devices can fail, you can use an interface configuration command to identify prestandard ports. A region cannot be formed between a standard and a prestandard device, but they can interoperate by using the CIST. Only the capability of load-balancing over different instances is lost in that particular case. The CLI displays different flags depending on the port configuration when a port receives prestandard BPDUs. A syslog message also appears the first time a device receives a prestandard BPDU on a port that has not been configured for prestandard BPDU transmission.

**Figure 49: Standard and Prestandard Device Interoperation**

Assume that A is a standard device and B a prestandard device, both configured to be in the same region. A is the root device for the CIST, and B has a root port (BX) on segment X and an alternate port (BY) on segment Y. If segment Y flaps, and the port on BY becomes the alternate before sending out a single prestandard BPDU, AY cannot detect that a prestandard device is connected to Y and continues to send standard BPDUs. The port BY is fixed in a boundary, and no load balancing is possible between A and B. The same problem exists on segment X, but B might transmit topology



**Note** We recommend that you minimize the interaction between standard and prestandard MST implementations.

## Detecting Unidirectional Link Failure

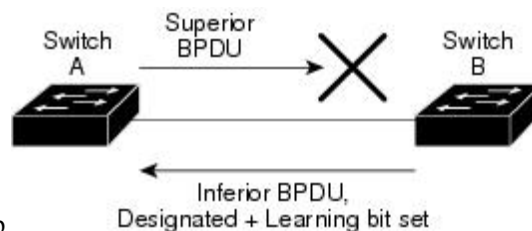
This feature is not yet present in the IEEE MST standard, but it is included in this Cisco IOS release. The software checks the consistency of the port role and state in the received BPDUs to detect unidirectional link failures that could cause bridging loops.

When a designated port detects a conflict, it keeps its role, but reverts to the discarding state because disrupting connectivity in case of inconsistency is preferable to opening a bridging loop.

**Figure 50: Detecting Unidirectional Link Failure**

This figure illustrates a unidirectional link failure that typically creates a bridging loop. Device A is the root device, and its BPDUs are lost on the link leading to device B. RSTP and MST BPDUs include the role and state of the sending port. With this information, device A can detect that device B does not react to the superior

BPDUs it sends and that device B is the designated, not root device. As a result, device A blocks (or keeps



blocking) its port, which prevents the bridging loop.

## MSTP and Device Stacks

A device stack appears as a single spanning-tree node to the rest of the network, and all stack members use the same bridge ID for a given spanning tree. The bridge ID is derived from the MAC address of the active switch.

The active switch is the stack root when the stack is the root of the network and no root selection has been made within the stack.

If the device stack is the spanning-tree root and the active switch fails or leaves the stack, the standby switch becomes the new active switch, bridge IDs remain the same, and a spanning-tree reconvergence might occur.

If a device that does not support MSTP is added to a device stack that does support MSTP or the reverse, the device is put into a version mismatch state. If possible, the device is automatically upgraded or downgraded to the same version of software that is running on the device stack.

## Interoperability with IEEE 802.1D STP

A device running MSTP supports a built-in protocol migration mechanism that enables it to interoperate with legacy IEEE 802.1D devices. If this device receives a legacy IEEE 802.1D configuration BPDU (a BPDU with the protocol version set to 0), it sends only IEEE 802.1D BPDUs on that port. An MSTP device also can detect that a port is at the boundary of a region when it receives a legacy BPDU, an MSTP BPDU (Version 3) associated with a different region, or an RSTP BPDU (Version 2).

However, the device does not automatically revert to the MSTP mode if it no longer receives IEEE 802.1D BPDUs because it cannot detect whether the legacy device has been removed from the link unless the legacy device is the designated device. A device might also continue to assign a boundary role to a port when the device to which this device is connected has joined the region. To restart the protocol migration process (force the renegotiation with neighboring devices), use the **clear spanning-tree detected-protocols** privileged EXEC command.

If all the legacy devices on the link are RSTP devices, they can process MSTP BPDUs as if they are RSTP BPDUs. Therefore, MSTP devices send either a Version 0 configuration and TCN BPDUs or Version 3 MSTP BPDUs on a boundary port. A boundary port connects to a LAN, the designated device of which is either a single spanning-tree device or a device with a different MST configuration.

## RSTP Overview

The RSTP takes advantage of point-to-point wiring and provides rapid convergence of the spanning tree. Reconfiguration of the spanning tree can occur in less than 1 second (in contrast to 50 seconds with the default settings in the IEEE 802.1D spanning tree).

## Port Roles and the Active Topology

The RSTP provides rapid convergence of the spanning tree by assigning port roles and by learning the active topology. The RSTP builds upon the IEEE 802.1D STP to select the device with the highest device priority (lowest numerical priority value) as the root device. The RSTP then assigns one of these port roles to individual ports:

- Root port—Provides the best path (lowest cost) when the device forwards packets to the root device.
- Designated port—Connects to the designated device, which incurs the lowest path cost when forwarding packets from that LAN to the root device. The port through which the designated device is attached to the LAN is called the designated port.
- Alternate port—Offers an alternate path toward the root device to that provided by the current root port.
- Backup port—Acts as a backup for the path provided by a designated port toward the leaves of the spanning tree. A backup port can exist only when two ports are connected in a loopback by a point-to-point link or when a device has two or more connections to a shared LAN segment.
- Disabled port—Has no role within the operation of the spanning tree.

A port with the root or a designated port role is included in the active topology. A port with the alternate or backup port role is excluded from the active topology.

In a stable topology with consistent port roles throughout the network, the RSTP ensures that every root port and designated port immediately transition to the forwarding state while all alternate and backup ports are always in the discarding state (equivalent to blocking in IEEE 802.1D). The port state controls the operation of the forwarding and learning processes.

**Table 56: Port State Comparison**

Operational Status	STP Port State (IEEE 802.1D)	RSTP Port State	Is Port Included in the Active Topology?
Enabled	Blocking	Discarding	No
Enabled	Listening	Discarding	No
Enabled	Learning	Learning	Yes
Enabled	Forwarding	Forwarding	Yes
Disabled	Disabled	Discarding	No

To be consistent with Cisco STP implementations, this guide defines the port state as *blocking* instead of *discarding*. Designated ports start in the listening state.

## Rapid Convergence

The RSTP provides for rapid recovery of connectivity following the failure of a device, a device port, or a LAN. It provides rapid convergence for edge ports, new root ports, and ports connected through point-to-point links as follows:

- Edge ports—If you configure a port as an edge port on an RSTP device by using the **spanning-tree portfast** interface configuration command, the edge port immediately transitions to the forwarding state.

An edge port is the same as a Port Fast-enabled port, and you should enable it only on ports that connect to a single end station.

- Root ports—If the RSTP selects a new root port, it blocks the old root port and immediately transitions the new root port to the forwarding state.
- Point-to-point links—If you connect a port to another port through a point-to-point link and the local port becomes a designated port, it negotiates a rapid transition with the other port by using the proposal-agreement handshake to ensure a loop-free topology.

**Figure 51: Proposal and Agreement Handshaking for Rapid Convergence**

Device A is connected to Device B through a point-to-point link, and all of the ports are in the blocking state. Assume that the priority of Device A is a smaller numerical value than the priority of Device B. Device A sends a proposal message (a configuration BPDU with the proposal flag set) to Device B, proposing itself as the designated device.

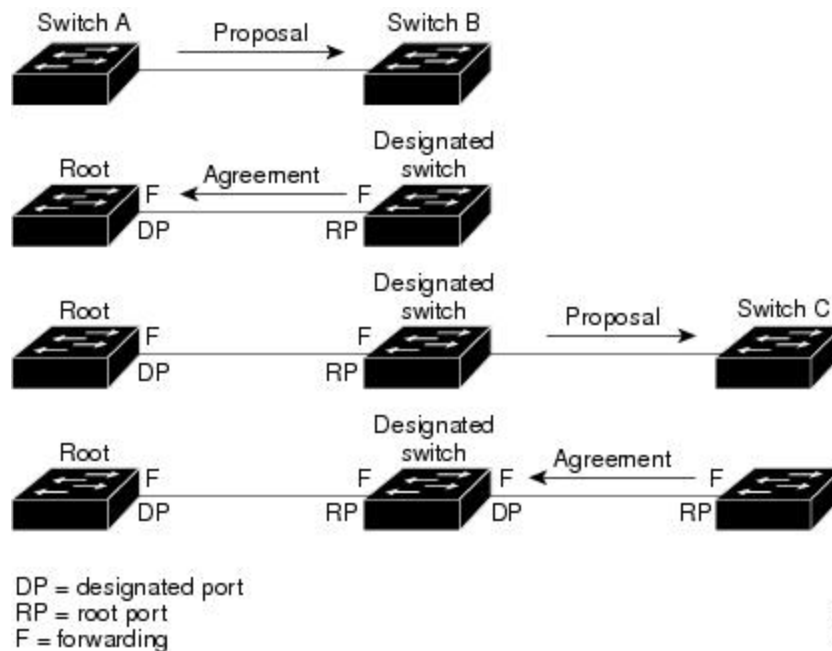
After receiving the proposal message, Device B selects as its new root port the port from which the proposal message was received, forces all nonedge ports to the blocking state, and sends an agreement message (a BPDU with the agreement flag set) through its new root port.

After receiving Device B's agreement message, Device A also immediately transitions its designated port to the forwarding state. No loops in the network are formed because Device B blocked all of its nonedge ports and because there is a point-to-point link between Devices A and B.

When Device C is connected to Device B, a similar set of handshaking messages are exchanged. Device C selects the port connected to Device B as its root port, and both ends immediately transition to the forwarding state. With each iteration of this handshaking process, one more device joins the active topology. As the network converges, this proposal-agreement handshaking progresses from the root toward the leaves of the spanning tree.

In a device stack, the cross-stack rapid transition (CSRT) feature ensures that a stack member receives acknowledgments from all stack members during the proposal-agreement handshaking before moving the port to the forwarding state. CSRT is automatically enabled when the device is in MST mode.

The device learns the link type from the port duplex mode: a full-duplex port is considered to have a point-to-point connection; a half-duplex port is considered to have a shared connection. You can override the default setting that is controlled by the duplex setting by using the **spanning-tree link-type** interface configuration command.



## Synchronization of Port Roles

When the device receives a proposal message on one of its ports and that port is selected as the new root port, the RSTP forces all other ports to synchronize with the new root information.

The device is synchronized with superior root information received on the root port if all other ports are synchronized. An individual port on the device is synchronized if

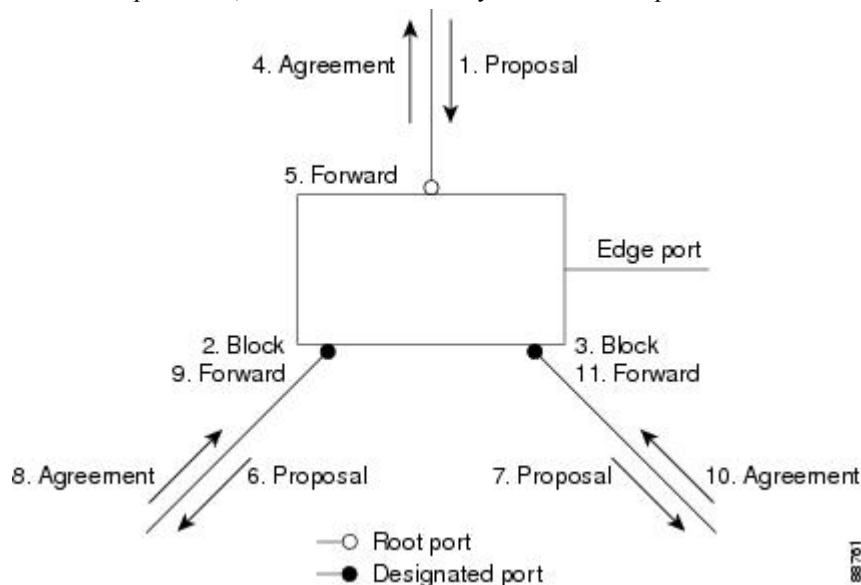
- That port is in the blocking state.
- It is an edge port (a port configured to be at the edge of the network).

If a designated port is in the forwarding state and is not configured as an edge port, it transitions to the blocking state when the RSTP forces it to synchronize with new root information. In general, when the RSTP forces a port to synchronize with root information and the port does not satisfy any of the above conditions, its port state is set to blocking.

### *Figure 52: Sequence of Events During Rapid Convergence*

After ensuring that all of the ports are synchronized, the device sends an agreement message to the designated device corresponding to its root port. When the devices connected by a point-to-point link are in agreement

about their port roles, the RSTP immediately transitions the port states to forwarding.



## Bridge Protocol Data Unit Format and Processing

The RSTP BPDU format is the same as the IEEE 802.1D BPDU format except that the protocol version is set to 2. A new 1-byte Version 1 Length field is set to zero, which means that no version 1 protocol information is present.

**Table 57: RSTP BPDU Flags**

Bit	Function
0	Topology change (TC)
1	Proposal
2–3:	Port role:
00	Unknown
01	Alternate port
10	Root port
11	Designated port
4	Learning
5	Forwarding
6	Agreement
7	Topology change acknowledgement (TCA)

The sending device sets the proposal flag in the RSTP BPDU to propose itself as the designated device on that LAN. The port role in the proposal message is always set to the designated port.



The sending device sets the agreement flag in the RSTP BPDU to accept the previous proposal. The port role in the agreement message is always set to the root port.

The RSTP does not have a separate topology change notification (TCN) BPDU. It uses the topology change (TC) flag to show the topology changes. However, for interoperability with IEEE 802.1D devices, the RSTP device processes and generates TCN BPDUs.

The learning and forwarding flags are set according to the state of the sending port.

### Processing Superior BPDU Information

If a port receives superior root information (lower device ID, lower path cost, and so forth) than currently stored for the port, the RSTP triggers a reconfiguration. If the port is proposed and is selected as the new root port, RSTP forces all the other ports to synchronize.

If the BPDU received is an RSTP BPDU with the proposal flag set, the device sends an agreement message after all of the other ports are synchronized. If the BPDU is an IEEE 802.1D BPDU, the device does not set the proposal flag and starts the forward-delay timer for the port. The new root port requires twice the forward-delay time to transition to the forwarding state.

If the superior information received on the port causes the port to become a backup or alternate port, RSTP sets the port to the blocking state but does not send the agreement message. The designated port continues sending BPDUs with the proposal flag set until the forward-delay timer expires, at which time the port transitions to the forwarding state.

### Processing Inferior BPDU Information

If a designated port receives an inferior BPDU (such as a higher device ID or a higher path cost than currently stored for the port) with a designated port role, it immediately replies with its own information.

## Topology Changes

This section describes the differences between the RSTP and the IEEE 802.1D in handling spanning-tree topology changes.

- **Detection**—Unlike IEEE 802.1D in which *any* transition between the blocking and the forwarding state causes a topology change, *only* transitions from the blocking to the forwarding state cause a topology change with RSTP (only an increase in connectivity is considered a topology change). State changes on an edge port do not cause a topology change. When an RSTP device detects a topology change, it deletes the learned information on all of its nonedge ports except on those from which it received the TC notification.
- **Notification**—Unlike IEEE 802.1D, which uses TCN BPDUs, the RSTP does not use them. However, for IEEE 802.1D interoperability, an RSTP device processes and generates TCN BPDUs.
- **Acknowledgement**—When an RSTP device receives a TCN message on a designated port from an IEEE 802.1D device, it replies with an IEEE 802.1D configuration BPDU with the TCA bit set. However, if the TC-while timer (the same as the topology-change timer in IEEE 802.1D) is active on a root port connected to an IEEE 802.1D device and a configuration BPDU with the TCA bit set is received, the TC-while timer is reset.

This behavior is only required to support IEEE 802.1D devices. The RSTP BPDUs never have the TCA bit set.

- **Propagation**—When an RSTP device receives a TC message from another device through a designated or root port, it propagates the change to all of its nonedge, designated ports and to the root port (excluding

the port on which it is received). The device starts the TC-while timer for all such ports and flushes the information learned on them.

- Protocol migration—For backward compatibility with IEEE 802.1D devices, RSTP selectively sends IEEE 802.1D configuration BPDUs and TCN BPDUs on a per-port basis.

When a port is initialized, the migrate-delay timer is started (specifies the minimum time during which RSTP BPDUs are sent), and RSTP BPDUs are sent. While this timer is active, the device processes all BPDUs received on that port and ignores the protocol type.

If the device receives an IEEE 802.1D BPDU after the port migration-delay timer has expired, it assumes that it is connected to an IEEE 802.1D device and starts using only IEEE 802.1D BPDUs. However, if the RSTP device is using IEEE 802.1D BPDUs on a port and receives an RSTP BPDU after the timer has expired, it restarts the timer and starts using RSTP BPDUs on that port.

## Protocol Migration Process

A device running MSTP supports a built-in protocol migration mechanism that enables it to interoperate with legacy IEEE 802.1D devices. If this device receives a legacy IEEE 802.1D configuration BPDU (a BPDU with the protocol version set to 0), it sends only IEEE 802.1D BPDUs on that port. An MSTP device also can detect that a port is at the boundary of a region when it receives a legacy BPDU, an MST BPDU (Version 3) associated with a different region, or an RST BPDU (Version 2).

However, the device does not automatically revert to the MSTP mode if it no longer receives IEEE 802.1D BPDUs because it cannot detect whether the legacy device has been removed from the link unless the legacy device is the designated device. A device also might continue to assign a boundary role to a port when the device to which it is connected has joined the region.

## Default MSTP Configuration

*Table 58: Default MSTP Configuration*

Feature	Default Setting
Spanning-tree mode	MSTP
Device priority (configurable on a per-CIST port basis)	32768
Spanning-tree port priority (configurable on a per-CIST port basis)	128
Spanning-tree port cost (configurable on a per-CIST port basis)	1000 Mb/s: 20000 100 Mb/s: 20000 10 Mb/s: 20000 1000 Mb/s: 20000 100 Mb/s: 20000 10 Mb/s: 20000
Hello time	3 seconds

Feature	Default Setting
Forward-delay time	20 seconds
Maximum-aging time	20 seconds
Maximum hop count	20 hops

## How to Configure MSTP Features

### Specifying the MST Region Configuration and Enabling MSTP (CLI)

For two or more switches to be in the same MST region, they must have the same VLAN-to-instance mapping, the same configuration revision number, and the same name.

A region can have one member or multiple members with the same MST configuration; each member must be capable of processing RSTP BPDUs. There is no limit to the number of MST regions in a network, but each region can only support up to 65 spanning-tree instances. You can assign a VLAN to only one spanning-tree instance at a time.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree mst configuration</b> <b>Example:</b> Device(config)# <b>spanning-tree mst configuration</b>	Enters MST configuration mode.
<b>Step 4</b>	<b>instance <i>instance-id</i> vlan <i>vlan-range</i></b> <b>Example:</b> Device(config-mst)# <b>instance 1 vlan 10-20</b>	Maps VLANs to an MST instance. <ul style="list-style-type: none"> <li>• For <i>instance-id</i>, the range is 0 to 4094.</li> <li>• For <b>vlan <i>vlan-range</i></b>, the range is 1 to 4094.</li> </ul> When you map VLANs to an MST instance, the mapping is incremental, and

	Command or Action	Purpose
		<p>the VLANs specified in the command are added to or removed from the VLANs that were previously mapped.</p> <p>To specify a VLAN range, use a hyphen; for example, <b>instance 1 vlan 1-63</b> maps VLANs 1 through 63 to MST instance 1.</p> <p>To specify a VLAN series, use a comma; for example, <b>instance 1 vlan 10, 20, 30</b> maps VLANs 10, 20, and 30 to MST instance 1.</p>
<b>Step 5</b>	<p><b>name</b> <i>name</i></p> <p><b>Example:</b></p> <pre>Device(config-mst) # name region1</pre>	Specifies the configuration name. The <i>name</i> string has a maximum length of 32 characters and is case sensitive.
<b>Step 6</b>	<p><b>revision</b> <i>version</i></p> <p><b>Example:</b></p> <pre>Device(config-mst) # revision 1</pre>	Specifies the configuration revision number. The range is 0 to 65535.
<b>Step 7</b>	<p><b>show pending</b></p> <p><b>Example:</b></p> <pre>Device(config-mst) # show pending</pre>	Verifies your configuration by displaying the pending configuration.
<b>Step 8</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-mst) # exit</pre>	Applies all changes, and returns to global configuration mode.
<b>Step 9</b>	<p><b>spanning-tree mode mst</b></p> <p><b>Example:</b></p> <pre>Device(config) # spanning-tree mode mst</pre>	<p>Enables MSTP. RSTP is also enabled.</p> <p>Changing spanning-tree modes can disrupt traffic because all spanning-tree instances are stopped for the previous mode and restarted in the new mode.</p> <p>You cannot run both MSTP and PVST+ or both MSTP and Rapid PVST+ at the same time.</p>
<b>Step 10</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config) # end</pre>	Returns to privileged EXEC mode.

## Configuring the Root Device (CLI)

This procedure is optional.

### Before you begin

A multiple spanning tree (MST) must be specified and enabled on the device. For instructions, see Related Topics.

You must also know the specified MST instance ID. Step 2 in the example uses 0 as the instance ID because that was the instance ID set up by the instructions listed under Related Topics.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree mst <i>instance-id</i> root primary</b> <b>Example:</b> Device(config)# <b>spanning-tree mst 0 root primary</b>	Configures a device as the root device. <ul style="list-style-type: none"> <li>• For <i>instance-id</i>, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 0 to 4094.</li> </ul>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring a Secondary Root Device (CLI)

When you configure a device with the extended system ID support as the secondary root, the device priority is modified from the default value (32768) to 28672. The device is then likely to become the root device for the specified instance if the primary root device fails. This is assuming that the other network devices use the default device priority of 32768 and therefore are unlikely to become the root device.

You can execute this command on more than one device to configure multiple backup root devices. Use the same network diameter and hello-time values that you used when you configured the primary root device with the **spanning-tree mst *instance-id* root primary** global configuration command.

This procedure is optional.

### Before you begin

A multiple spanning tree (MST) must be specified and enabled on the device. For instructions, see Related Topics.

You must also know the specified MST instance ID. This example uses 0 as the instance ID because that was the instance ID set up by the instructions listed under Related Topics.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree mst <i>instance-id</i> root secondary</b> <b>Example:</b> Device(config)# <b>spanning-tree mst 0 root secondary</b>	Configures a device as the secondary root device. <ul style="list-style-type: none"> <li>• For <i>instance-id</i>, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 0 to 4094.</li> </ul>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring Port Priority (CLI)

If a loop occurs, the MSTP uses the port priority when selecting an interface to put into the forwarding state. You can assign higher priority values (lower numerical values) to interfaces that you want selected first and lower priority values (higher numerical values) that you want selected last. If all interfaces have the same priority value, the MSTP puts the interface with the lowest interface number in the forwarding state and blocks the other interfaces.



**Note** If the device is a member of a device stack, you must use the **spanning-tree mst [instance-id] cost cost** interface configuration command instead of the **spanning-tree mst [instance-id] port-priority priority** interface configuration command to select a port to put in the forwarding state. Assign lower cost values to ports that you want selected first and higher cost values to ports that you want selected last. For more information, see the path costs topic listed under Related Topics.

This procedure is optional.

### Before you begin

A multiple spanning tree (MST) must be specified and enabled on the device. For instructions, see Related Topics.

You must also know the specified MST instance ID and the interface used. This example uses 0 as the instance ID and GigabitEthernet0/1 as the interface because that was the instance ID and interface set up by the instructions listed under Related Topics.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface interface-id</b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/1</b>	Specifies an interface to configure, and enters interface configuration mode.
<b>Step 4</b>	<b>spanning-tree mst instance-id port-priority priority</b> <b>Example:</b> Device(config-if)# <b>spanning-tree mst 0 port-priority 64</b>	Configures port priority. <ul style="list-style-type: none"> <li>• For <i>instance-id</i>, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 0 to 4094.</li> <li>• For <i>priority</i>, the range is 0 to 240 in increments of 16. The default is 128. The lower the number, the higher the priority.</li> </ul>

	Command or Action	Purpose
		The priority values are 0, 16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, and 240. All other values are rejected.
<b>Step 5</b>	<b>end</b>  <b>Example:</b>  Device(config-if) # <b>end</b>	Returns to privileged EXEC mode.

The **show spanning-tree mst interface *interface-id*** privileged EXEC command displays information only if the port is in a link-up operative state. Otherwise, you can use the **show running-config interface** privileged EXEC command to confirm the configuration.

## Configuring Path Cost (CLI)

The MSTP path cost default value is derived from the media speed of an interface. If a loop occurs, the MSTP uses cost when selecting an interface to put in the forwarding state. You can assign lower cost values to interfaces that you want selected first and higher cost values that you want selected last. If all interfaces have the same cost value, the MSTP puts the interface with the lowest interface number in the forwarding state and blocks the other interfaces.

This procedure is optional.

### Before you begin

A multiple spanning tree (MST) must be specified and enabled on the device. For instructions, see Related Topics.

You must also know the specified MST instance ID and the interface used. This example uses 0 as the instance ID and GigabitEthernet1/0/1 as the interface because that was the instance ID and interface set up by the instructions listed under Related Topics.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.



	Command or Action	Purpose
<b>Step 3</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> Device(config)# <b>interface</b> gigabitethernet 1/0/1	Specifies an interface to configure, and enters interface configuration mode. Valid interfaces include physical ports and port-channel logical interfaces. The port-channel range is 1 to 48.
<b>Step 4</b>	<b>spanning-tree mst</b> <i>instance-id</i> <b>cost</b> <i>cost</i> <b>Example:</b> Device(config-if)# <b>spanning-tree mst</b> 0 <b>cost</b> 17031970	Configures the cost. If a loop occurs, the MSTP uses the path cost when selecting an interface to place into the forwarding state. A lower path cost represents higher-speed transmission. <ul style="list-style-type: none"> <li>• For <i>instance-id</i>, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 0 to 4094.</li> <li>• For <i>cost</i>, the range is 1 to 200000000; the default value is derived from the media speed of the interface.</li> </ul>
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

The **show spanning-tree mst interface** *interface-id* privileged EXEC command displays information only for ports that are in a link-up operative state. Otherwise, you can use the **show running-config** privileged EXEC command to confirm the configuration.

## Configuring the Device Priority (CLI)

Changing the priority of a device makes it more likely to be chosen as the root device whether it is a standalone device or a device in the stack.



**Note** Exercise care when using this command. For normal network configurations, we recommend that you use the **spanning-tree mst** *instance-id* **root primary** and the **spanning-tree mst** *instance-id* **root secondary** global configuration commands to specify a device as the root or secondary root device. You should modify the device priority only in circumstances where these commands do not work.

This procedure is optional.

### Before you begin

A multiple spanning tree (MST) must be specified and enabled on the device. For instructions, see Related Topics.

You must also know the specified MST instance ID used. This example uses 0 as the instance ID because that was the instance ID set up by the instructions listed under Related Topics.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree mst <i>instance-id</i> priority <i>priority</i></b> <b>Example:</b> Device(config)# <b>spanning-tree mst 0 priority 40960</b>	Configures the device priority. <ul style="list-style-type: none"> <li>• For <i>instance-id</i>, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 0 to 4094.</li> <li>• For <i>priority</i>, the range is 0 to 61440 in increments of 4096; the default is 32768. The lower the number, the more likely the device will be chosen as the root device.</li> </ul> Priority values are 0, 4096, 8192, 12288, 16384, 20480, 24576, 28672, 32768, 36864, 40960, 45056, 49152, 53248, 57344, and 61440. These are the only acceptable values.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring the Hello Time (CLI)

The hello time is the time interval between configuration messages generated and sent by the root device. This procedure is optional.

### Before you begin

A multiple spanning tree (MST) must be specified and enabled on the device. For instructions, see Related Topics.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree mst hello-time <i>seconds</i></b> <b>Example:</b> Device(config)# <b>spanning-tree mst hello-time 4</b>	Configures the hello time for all MST instances. The hello time is the time interval between configuration messages generated and sent by the root device. These messages indicate that the device is alive.  For <i>seconds</i> , the range is 1 to 10; the default is 3.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring the Forwarding-Delay Time (CLI)

**Before you begin**

A multiple spanning tree (MST) must be specified and enabled on the device. For instructions, see Related Topics.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 3</b>	<b>spanning-tree mst forward-time <i>seconds</i></b> <b>Example:</b> Device(config)# <code>spanning-tree mst forward-time 25</code>	Configures the forward time for all MST instances. The forwarding delay is the number of seconds a port waits before changing from its spanning-tree learning and listening states to the forwarding state.  For <i>seconds</i> , the range is 4 to 30; the default is 20.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.

## Configuring the Maximum-Aging Time (CLI)

### Before you begin

A multiple spanning tree (MST) must be specified and enabled on the device. For instructions, see Related Topics.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree mst max-age <i>seconds</i></b> <b>Example:</b> Device(config)# <code>spanning-tree mst max-age 40</code>	Configures the maximum-aging time for all MST instances. The maximum-aging time is the number of seconds a device waits without receiving spanning-tree configuration messages before attempting a reconfiguration.  For <i>seconds</i> , the range is 6 to 40; the default is 20.

	Command or Action	Purpose
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config) # <b>end</b>	Returns to privileged EXEC mode.

## Configuring the Maximum-Hop Count (CLI)

This procedure is optional.

### Before you begin

A multiple spanning tree (MST) must be specified and enabled on the device. For instructions, see Related Topics.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree mst max-hops <i>hop-count</i></b> <b>Example:</b> Device(config) # <b>spanning-tree mst max-hops 25</b>	Specifies the number of hops in a region before the BPDU is discarded, and the information held for a port is aged.  For <i>hop-count</i> , the range is 1 to 255; the default is 20.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config) # <b>end</b>	Returns to privileged EXEC mode.

## Specifying the Link Type to Ensure Rapid Transitions (CLI)

If you connect a port to another port through a point-to-point link and the local port becomes a designated port, the RSTP negotiates a rapid transition with the other port by using the proposal-agreement handshake to ensure a loop-free topology.

By default, the link type is controlled from the duplex mode of the interface: a full-duplex port is considered to have a point-to-point connection; a half-duplex port is considered to have a shared connection. If you have a half-duplex link physically connected point-to-point to a single port on a remote device running MSTP, you can override the default setting of the link type and enable rapid transitions to the forwarding state.

This procedure is optional.

### Before you begin

A multiple spanning tree (MST) must be specified and enabled on the device. For instructions, see Related Topics.

You must also know the specified MST instance ID and the interface used. This example uses 0 as the instance ID and GigabitEthernet1/0/1 as the interface because that was the instance ID and interface set up by the instructions listed under Related Topics.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/1</b>	Specifies an interface to configure, and enters interface configuration mode. Valid interfaces include physical ports, VLANs, and port-channel logical interfaces. The VLAN ID range is 1 to 4094. The port-channel range is 1 to 48.
<b>Step 4</b>	<b>spanning-tree link-type point-to-point</b> <b>Example:</b> Device(config-if)# <b>spanning-tree link-type point-to-point</b>	Specifies that the link type of a port is point-to-point.
<b>Step 5</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	Device(config-if)# <b>end</b>	

## Designating the Neighbor Type (CLI)

A topology could contain both prestandard and IEEE 802.1s standard compliant devices. By default, ports can automatically detect prestandard devices, but they can still receive both standard and prestandard BPDUs. When there is a mismatch between a device and its neighbor, only the CIST runs on the interface.

You can choose to set a port to send only prestandard BPDUs. The prestandard flag appears in all the **show** commands, even if the port is in STP compatibility mode.

This procedure is optional.

### Before you begin

A multiple spanning tree (MST) must be specified and enabled on the device. For instructions, see Related Topics.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device(config)# <b>interface gigabitethernet 1/0/1</b>	Specifies an interface to configure, and enters interface configuration mode. Valid interfaces include physical ports.
<b>Step 4</b>	<b>spanning-tree mst pre-standard</b> <b>Example:</b>  Device(config-if)# <b>spanning-tree mst pre-standard</b>	Specifies that the port can send only prestandard BPDUs.
<b>Step 5</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	Device (config-if) # <b>end</b>	

## Restarting the Protocol Migration Process (CLI)

This procedure restarts the protocol migration process and forces renegotiation with neighboring devices. It reverts the device to MST mode. It is needed when the device no longer receives IEEE 802.1D BPDUs after it has been receiving them.

Follow these steps to restart the protocol migration process (force the renegotiation with neighboring devices) on the device.

### Before you begin

A multiple spanning tree (MST) must be specified and enabled on the device. For instructions, see Related Topics.

If you want to use the interface version of the command, you must also know the MST interface used. This example uses GigabitEthernet1/0/1 as the interface because that was the interface set up by the instructions listed under Related Topics.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	Enter one of the following commands: <ul style="list-style-type: none"> <li>• <b>clear spanning-tree detected-protocols</b></li> <li>• <b>clear spanning-tree detected-protocols interface <i>interface-id</i></b></li> </ul> <b>Example:</b> Device# <b>clear spanning-tree detected-protocols</b>  or Device# <b>clear spanning-tree detected-protocols interface gigabitethernet 1/0/1</b>	The device reverts to the MSTP mode, and the protocol migration process restarts.

### What to do next

This procedure may need to be repeated if the device receives more legacy IEEE 802.1D configuration BPDUs (BPDUs with the protocol version set to 0).



## Additional References for MSTP

### Related Documents

Related Topic	Document Title
Spanning tree protocol commands	<i>LAN Switching Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>

### Standards and RFCs

Standard/RFC	Title
None	—

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for MSTP

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.





# CHAPTER 46

## Configuring Optional Spanning-Tree Features

- [Information About Optional Spanning-Tree Features](#), on page 781
- [How to Configure Optional Spanning-Tree Features](#), on page 790
- [Monitoring the Spanning-Tree Status](#), on page 799
- [Additional References for Optional Spanning Tree Features](#), on page 800
- [Feature Information for Optional Spanning-Tree Features](#), on page 801

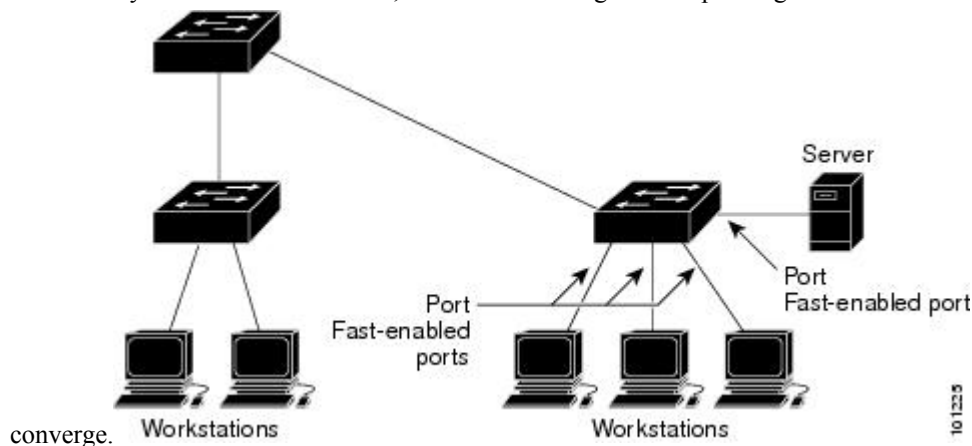
### Information About Optional Spanning-Tree Features

#### PortFast

PortFast immediately brings an interface configured as an access or trunk port to the forwarding state from a blocking state, bypassing the listening and learning states.

**Figure 53: PortFast-Enabled Interfaces**

You can use PortFast on interfaces connected to a single workstation or server to allow those devices to immediately connect to the network, rather than waiting for the spanning tree to



Interfaces connected to a single workstation or server should not receive bridge protocol data units (BPDUs). An interface with PortFast enabled goes through the normal cycle of spanning-tree status changes when the switch is restarted.

You can enable this feature by enabling it on either the interface or on all nontrunking ports.

## BPDU Guard

The Bridge Protocol Data Unit (BPDU) guard feature can be globally enabled on the switch or can be enabled per port, but the feature operates with some differences.

When you enable BPDU guard at the global level on PortFast edge-enabled ports, spanning tree shuts down ports that are in a PortFast edge-operational state if any BPDU is received on them. In a valid configuration, PortFast edge-enabled ports do not receive BPDUs. Receiving a BPDU on a Port Fast edge-enabled port means an invalid configuration, such as the connection of an unauthorized device, and the BPDU guard feature puts the port in the error-disabled state. When this happens, the switch shuts down the entire port on which the violation occurred.

When you enable BPDU guard at the interface level on any port without also enabling the PortFast edge feature, and the port receives a BPDU, it is put in the error-disabled state.

The BPDU guard feature provides a secure response to invalid configurations because you must manually put the interface back in service. Use the BPDU guard feature in a service-provider network to prevent an access port from participating in the spanning tree.

## BPDU Filtering

The BPDU filtering feature can be globally enabled on the switch or can be enabled per interface, but the feature operates with some differences.

Enabling BPDU filtering on PortFast edge-enabled interfaces at the global level keeps those interfaces that are in a PortFast edge-operational state from sending or receiving BPDUs. The interfaces still send a few BPDUs at link-up before the switch begins to filter outbound BPDUs. You should globally enable BPDU filtering on a switch so that hosts connected to these interfaces do not receive BPDUs. If a BPDU is received on a PortFast edge-enabled interface, the interface loses its PortFast edge-operational status, and BPDU filtering is disabled.

Enabling BPDU filtering on an interface without also enabling the PortFast edge feature keeps the interface from sending or receiving BPDUs.

**Caution**

Enabling BPDU filtering on an interface is the same as disabling spanning tree on it and can result in spanning-tree loops.

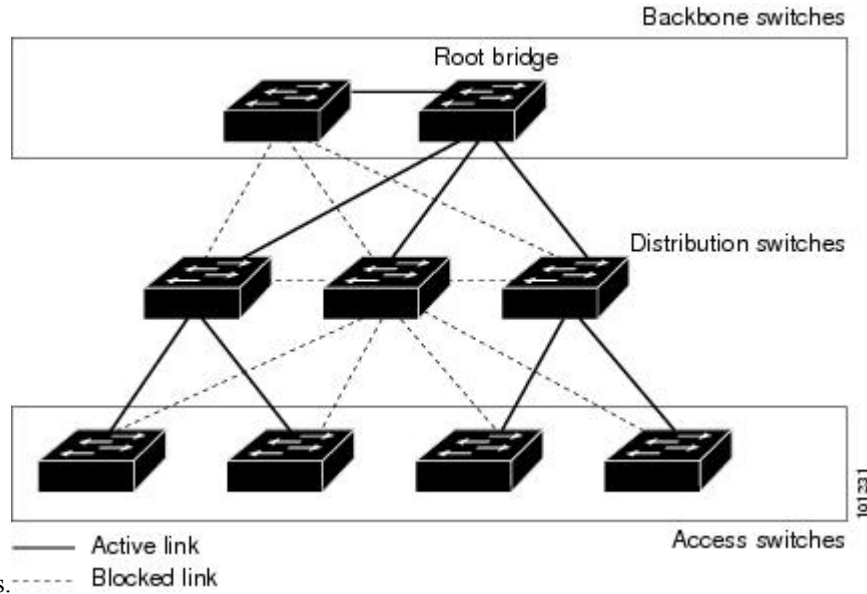
You can enable the BPDU filtering feature for the entire switch or for an interface.

## UplinkFast

*Figure 54: Switches in a Hierarchical Network*

Switches in hierarchical networks can be grouped into backbone switches, distribution switches, and access switches. This complex network has distribution switches and access switches that each have at least one

redundant link that spanning tree blocks to prevent



loops.----- Blocked link

If a switch loses connectivity, it begins using the alternate paths as soon as the spanning tree selects a new root port. You can accelerate the choice of a new root port when a link or switch fails or when the spanning tree reconfigures itself by enabling UplinkFast. The root port transitions to the forwarding state immediately without going through the listening and learning states, as it would with the normal spanning-tree procedures.

When the spanning tree reconfigures the new root port, other interfaces flood the network with multicast packets, one for each address that was learned on the interface. You can limit these bursts of multicast traffic by reducing the max-update-rate parameter (the default for this parameter is 150 packets per second). However, if you enter zero, station-learning frames are not generated, so the spanning-tree topology converges more slowly after a loss of connectivity.

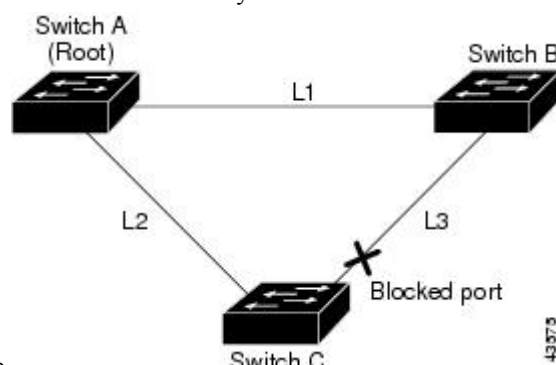


**Note** UplinkFast is most useful in wiring-closet switches at the access or edge of the network. It is not appropriate for backbone devices. This feature might not be useful for other types of applications.

UplinkFast provides fast convergence after a direct link failure and achieves load-balancing between redundant Layer 2 links using uplink groups. An uplink group is a set of Layer 2 interfaces (per VLAN), only one of which is forwarding at any given time. Specifically, an uplink group consists of the root port (which is forwarding) and a set of blocked ports, except for self-looping ports. The uplink group provides an alternate path in case the currently forwarding link fails.

**Figure 55: UplinkFast Example Before Direct Link Failure**

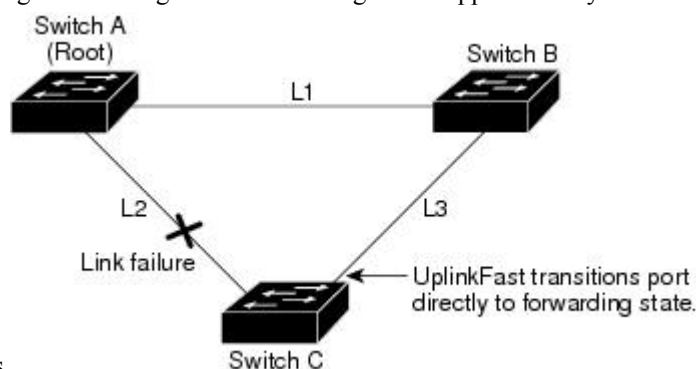
This topology has no link failures. Switch A, the root switch, is connected directly to Switch B over link L1 and to Switch C over link L2. The Layer 2 interface on Switch C that is connected directly to Switch B is in



a blocking state.

**Figure 56: UplinkFast Example After Direct Link Failure**

If Switch C detects a link failure on the currently active link L2 on the root port (a direct link failure), UplinkFast unblocks the blocked interface on Switch C and transitions it to the forwarding state without going through the listening and learning states. This change takes approximately 1 to



5 seconds.

## Cross-Stack UplinkFast

Cross-Stack UplinkFast (CSUF) provides a fast spanning-tree transition (fast convergence in less than 1 second under normal network conditions) across a switch stack. During the fast transition, an alternate redundant link on the switch stack is placed in the forwarding state without causing temporary spanning-tree loops or loss of connectivity to the backbone. With this feature, you can have a redundant and resilient network in some configurations. CSUF is automatically enabled when you enable the UplinkFast feature.

CSUF might not provide a fast transition all the time; in these cases, the normal spanning-tree transition occurs, completing in 30 to 40 seconds. For more information, see Related Topics.

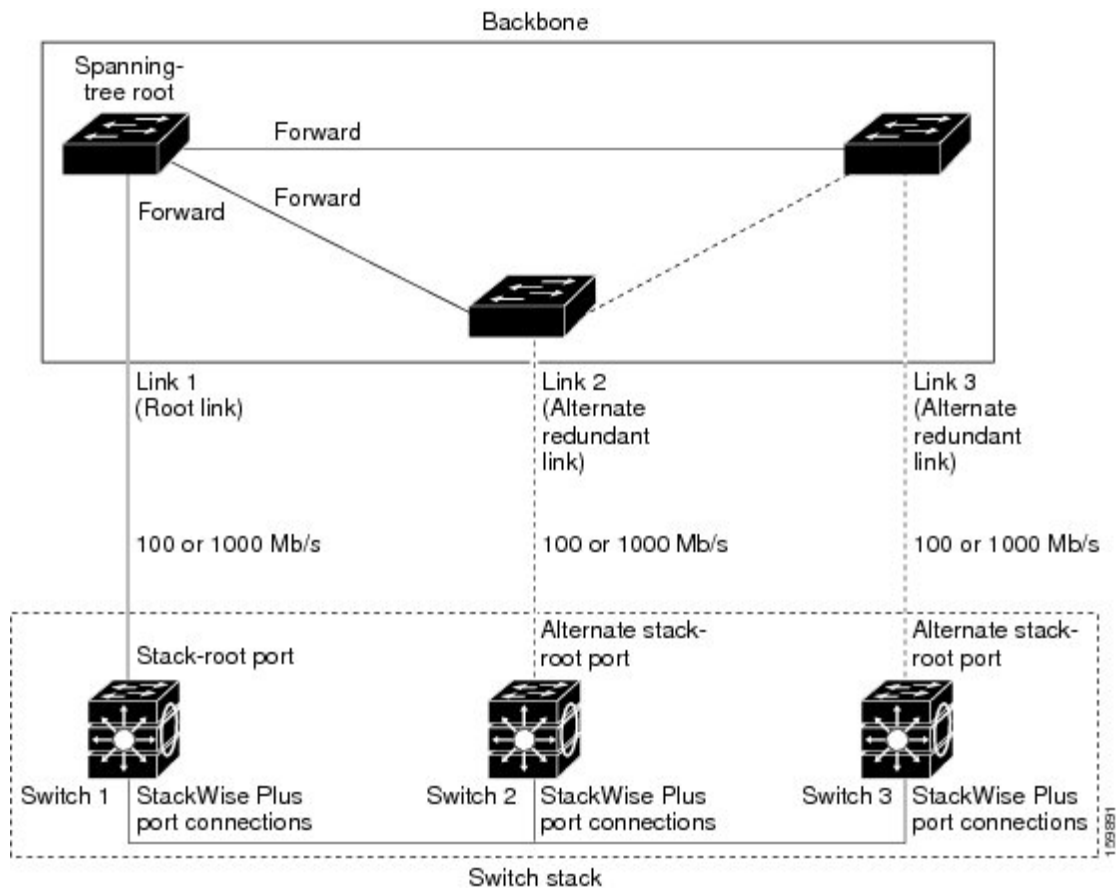
## How Cross-Stack UplinkFast Works

Cross-Stack UplinkFast (CSUF) ensures that one link in the stack is elected as the path to the root.

**Figure 57: Cross-Stack UplinkFast Topology**

The stack-root port on Switch 1 provides the path to the root of the spanning tree. The alternate stack-root ports on Switches 2 and 3 can provide an alternate path to the spanning-tree root if the current stack-root switch fails or if its link to the spanning-tree root fails.

Link 1, the root link, is in the spanning-tree forwarding state. Links 2 and 3 are alternate redundant links that are in the spanning-tree blocking state. If Switch 1 fails, if its stack-root port fails, or if Link 1 fails, CSUF selects either the alternate stack-root port on Switch 2 or Switch 3 and puts it into the forwarding state in less than 1 second.



When certain link loss or spanning-tree events occur (described in the following topic), the Fast Uplink Transition Protocol uses the neighbor list to send fast-transition requests to stack members.

The switch sending the fast-transition request needs to do a fast transition to the forwarding state of a port that it has chosen as the root port, and it must obtain an acknowledgment from each stack switch before performing the fast transition.

Each switch in the stack decides if the sending switch is a better choice than itself to be the stack root of this spanning-tree instance by comparing the root, cost, and bridge ID. If the sending switch is the best choice as the stack root, each switch in the stack returns an acknowledgment; otherwise, it sends a fast-transition request. The sending switch then has not received acknowledgments from all stack switches.

When acknowledgments are received from all stack switches, the Fast Uplink Transition Protocol on the sending switch immediately transitions its alternate stack-root port to the forwarding state. If acknowledgments

from all stack switches are not obtained by the sending switch, the normal spanning-tree transitions (blocking, listening, learning, and forwarding) take place, and the spanning-tree topology converges at its normal rate ( $2 * \text{forward-delay time} + \text{max-age time}$ ).

The Fast Uplink Transition Protocol is implemented on a per-VLAN basis and affects only one spanning-tree instance at a time.

## Events That Cause Fast Convergence

Depending on the network event or failure, the CSUF fast convergence might or might not occur.

Fast convergence (less than 1 second under normal network conditions) occurs under these circumstances:

- The stack-root port link fails.  
If two switches in the stack have alternate paths to the root, only one of the switches performs the fast transition.
- The failed link, which connects the stack root to the spanning-tree root, recovers.
- A network reconfiguration causes a new stack-root switch to be selected.
- A network reconfiguration causes a new port on the current stack-root switch to be chosen as the stack-root port.




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**Note** The fast transition might not occur if multiple events occur simultaneously. For example, if a stack member is powered off, and at the same time, the link connecting the stack root to the spanning-tree root comes back up, the normal spanning-tree convergence occurs.

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Normal spanning-tree convergence (30 to 40 seconds) occurs under these conditions:

- The stack-root switch is powered off, or the software failed.
- The stack-root switch, which was powered off or failed, is powered on.
- A new switch, which might become the stack root, is added to the stack.

## BackboneFast

BackboneFast detects indirect failures in the core of the backbone. BackboneFast is a complementary technology to the UplinkFast feature, which responds to failures on links directly connected to access switches.

BackboneFast optimizes the maximum-age timer, which controls the amount of time the switch stores protocol information received on an interface. When a switch receives an inferior BPDU from the designated port of another switch, the BPDU is a signal that the other switch might have lost its path to the root, and BackboneFast tries to find an alternate path to the root.

BackboneFast starts when a root port or blocked interface on a switch receives inferior BPDUs from its designated switch. An inferior BPDU identifies a switch that declares itself as both the root bridge and the designated switch. When a switch receives an inferior BPDU, it means that a link to which the switch is not directly connected (an indirect link) has failed (that is, the designated switch has lost its connection to the root switch). Under spanning-tree rules, the switch ignores inferior BPDUs for the maximum aging time (default is 20 seconds).



The switch tries to find if it has an alternate path to the root switch. If the inferior BPDU arrives on a blocked interface, the root port and other blocked interfaces on the switch become alternate paths to the root switch. (Self-looped ports are not considered alternate paths to the root switch.) If the inferior BPDU arrives on the root port, all blocked interfaces become alternate paths to the root switch. If the inferior BPDU arrives on the root port and there are no blocked interfaces, the switch assumes that it has lost connectivity to the root switch, causes the maximum aging time on the root port to expire, and becomes the root switch according to normal spanning-tree rules.

If the switch has alternate paths to the root switch, it uses these alternate paths to send a root link query (RLQ) request. The switch sends the RLQ request on all alternate paths to learn if any stack member has an alternate root to the root switch and waits for an RLQ reply from other switches in the network and in the stack. The switch sends the RLQ request on all alternate paths and waits for an RLQ reply from other switches in the network.

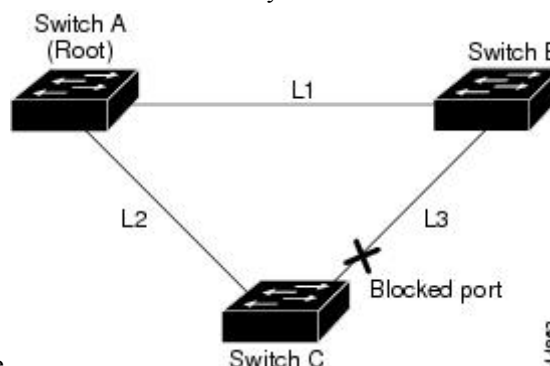
When a stack member receives an RLQ reply from a nonstack member on a blocked interface and the reply is destined for another nonstacked switch, it forwards the reply packet, regardless of the spanning-tree interface state.

When a stack member receives an RLQ reply from a nonstack member and the response is destined for the stack, the stack member forwards the reply so that all the other stack members receive it.

If the switch discovers that it still has an alternate path to the root, it expires the maximum aging time on the interface that received the inferior BPDU. If all the alternate paths to the root switch indicate that the switch has lost connectivity to the root switch, the switch expires the maximum aging time on the interface that received the RLQ reply. If one or more alternate paths can still connect to the root switch, the switch makes all interfaces on which it received an inferior BPDU its designated ports and moves them from the blocking state (if they were in the blocking state), through the listening and learning states, and into the forwarding state.

**Figure 58: BackboneFast Example Before Indirect Link Failure**

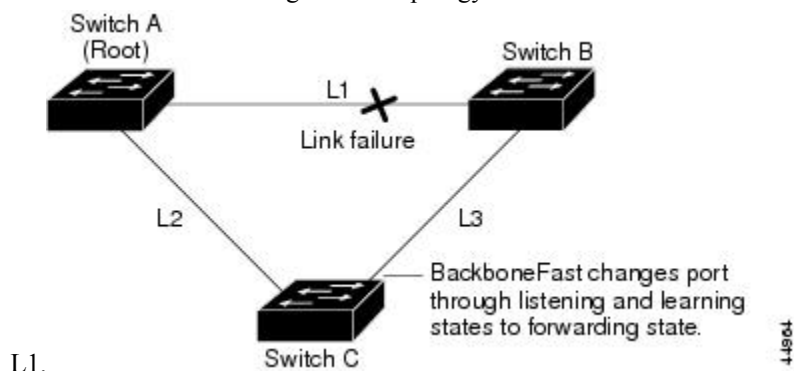
This is an example topology with no link failures. Switch A, the root switch, connects directly to Switch B over link L1 and to Switch C over link L2. The Layer 2 interface on Switch C that connects directly to Switch B



**Figure 59: BackboneFast Example After Indirect Link Failure**

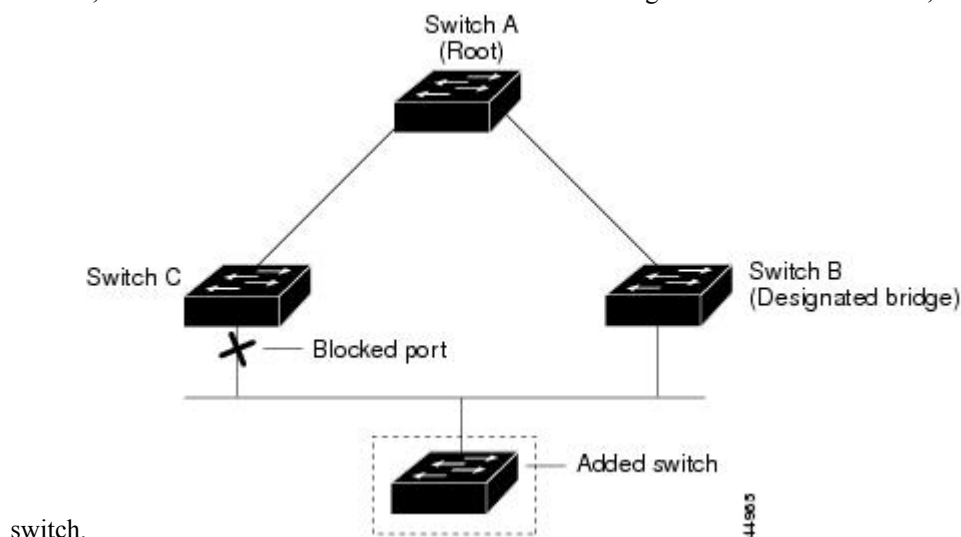
If link L1 fails, Switch C cannot detect this failure because it is not connected directly to link L1. However, because Switch B is directly connected to the root switch over L1, it detects the failure, elects itself the root, and begins sending BPDUs to Switch C, identifying itself as the root. When Switch C receives the inferior BPDUs from Switch B, Switch C assumes that an indirect failure has occurred. At that point, BackboneFast allows the blocked interface on Switch C to move immediately to the listening state without waiting for the maximum aging time for the interface to expire. BackboneFast then transitions the Layer 2 interface on Switch C to the forwarding state, providing a path from Switch B to Switch A. The root-switch election takes

approximately 30 seconds, twice the Forward Delay time if the default Forward Delay time of 15 seconds is set. BackboneFast reconfigures the topology to account for the failure of link



**Figure 60: Adding a Switch in a Shared-Medium Topology**

If a new switch is introduced into a shared-medium topology, BackboneFast is not activated because the inferior BPDUs did not come from the recognized designated switch (Switch B). The new switch begins sending inferior BPDUs that indicate it is the root switch. However, the other switches ignore these inferior BPDUs, and the new switch learns that Switch B is the designated switch to Switch A, the root



## EtherChannel Guard

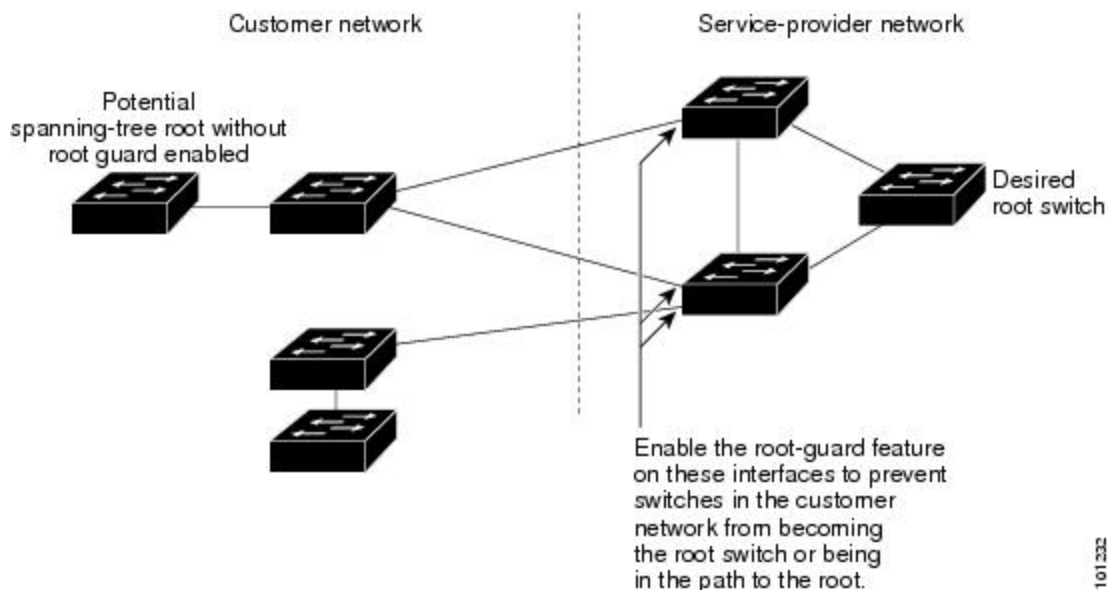
You can use EtherChannel guard to detect an EtherChannel misconfiguration between the switch and a connected device. A misconfiguration can occur if the switch interfaces are configured in an EtherChannel, but the interfaces on the other device are not. A misconfiguration can also occur if the channel parameters are not the same at both ends of the EtherChannel.

If the switch detects a misconfiguration on the other device, EtherChannel guard places the switch interfaces in the error-disabled state, and displays an error message.

## Root Guard

**Figure 61: Root Guard in a Service-Provider Network**

The Layer 2 network of a service provider (SP) can include many connections to switches that are not owned by the SP. In such a topology, the spanning tree can reconfigure itself and select a customer switch as the root switch. You can avoid this situation by enabling root guard on SP switch interfaces that connect to switches in your customer's network. If spanning-tree calculations cause an interface in the customer network to be selected as the root port, root guard then places the interface in the root-inconsistent (blocked) state to prevent the customer's switch from becoming the root switch or being in the path to the root.



If a switch outside the SP network becomes the root switch, the interface is blocked (root-inconsistent state), and spanning tree selects a new root switch. The customer's switch does not become the root switch and is not in the path to the root.

If the switch is operating in multiple spanning-tree (MST) mode, root guard forces the interface to be a designated port. If a boundary port is blocked in an internal spanning-tree (IST) instance because of root guard, the interface also is blocked in all MST instances. A boundary port is an interface that connects to a LAN, the designated switch of which is either an IEEE 802.1D switch or a switch with a different MST region configuration.

Root guard enabled on an interface applies to all the VLANs to which the interface belongs. VLANs can be grouped and mapped to an MST instance.



### Caution

Misuse of the root guard feature can cause a loss of connectivity.

## Loop Guard

You can use loop guard to prevent alternate or root ports from becoming designated ports because of a failure that leads to a unidirectional link. This feature is most effective when it is enabled on the entire switched

network. Loop guard prevents alternate and root ports from becoming designated ports, and spanning tree does not send BPDUs on root or alternate ports.

When the switch is operating in PVST+ or rapid-PVST+ mode, loop guard prevents alternate and root ports from becoming designated ports, and spanning tree does not send BPDUs on root or alternate ports.

When the switch is operating in MST mode, BPDUs are not sent on nonboundary ports only if the interface is blocked by loop guard in all MST instances. On a boundary port, loop guard blocks the interface in all MST instances.

## How to Configure Optional Spanning-Tree Features

### Enabling PortFast (CLI)

An interface with the PortFast feature enabled is moved directly to the spanning-tree forwarding state without waiting for the standard forward-time delay.

If you enable the voice VLAN feature, the PortFast feature is automatically enabled. When you disable voice VLAN, the PortFast feature is not automatically disabled.

You can enable this feature if your switch is running PVST+, Rapid PVST+, or MSTP.



#### Caution

Use PortFast only when connecting a single end station to an access or trunk port. Enabling this feature on an interface connected to a switch or hub could prevent spanning tree from detecting and disabling loops in your network, which could cause broadcast storms and address-learning problems.

This procedure is optional.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device (config) # <b>interface gigabitethernet</b>	Specifies an interface to configure, and enters interface configuration mode.

	Command or Action	Purpose
	1/0/2	
<b>Step 4</b>	<b>spanning-tree portfast [trunk]</b> <b>Example:</b> Device(config-if)# <b>spanning-tree portfast trunk</b>	Enables PortFast on an access port connected to a single workstation or server. By specifying the <b>trunk</b> keyword, you can enable PortFast on a trunk port. <b>Note</b> To enable PortFast on trunk ports, you must use the <b>spanning-tree portfast trunk</b> interface configuration command. The <b>spanning-tree portfast</b> command will not work on trunk ports. Make sure that there are no loops in the network between the trunk port and the workstation or server before you enable PortFast on a trunk port. By default, PortFast is disabled on all interfaces.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

**What to do next**

You can use the **spanning-tree portfast default** global configuration command to globally enable the PortFast feature on all nontrunking ports.

## Enabling BPDU Guard (CLI)

You can enable the BPDU guard feature if your switch is running PVST+, Rapid PVST+, or MSTP.

**Caution**

Configure PortFast edge only on ports that connect to end stations; otherwise, an accidental topology loop could cause a data packet loop and disrupt switch and network operation.

This procedure is optional.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
	Device> <b>enable</b>	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device (config) # <b>interface gigabitethernet 1/0/2</b>	Specifies the interface connected to an end station, and enters interface configuration mode.
<b>Step 4</b>	<b>spanning-tree portfast edge</b> <b>Example:</b> Device (config-if) # <b>spanning-tree portfast edge</b>	Enables the PortFast edge feature.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device (config-if) # <b>end</b>	Returns to privileged EXEC mode.

**What to do next**

To prevent the port from shutting down, you can use the **errdisable detect cause bpduguard shutdown vlan** global configuration command to shut down just the offending VLAN on the port where the violation occurred.

You also can use the **spanning-tree bpduguard enable** interface configuration command to enable BPDU guard on any port without also enabling the PortFast edge feature. When the port receives a BPDU, it is put it in the error-disabled state.

**Enabling BPDU Filtering (CLI)**

You can also use the **spanning-tree bpdupfilter enable** interface configuration command to enable BPDU filtering on any interface without also enabling the PortFast edge feature. This command prevents the interface from sending or receiving BPDUs.

**Caution**

Enabling BPDU filtering on an interface is the same as disabling spanning tree on it and can result in spanning-tree loops.

You can enable the BPDU filtering feature if your switch is running PVST+, Rapid PVST+, or MSTP.

**Caution**

Configure PortFast edge only on interfaces that connect to end stations; otherwise, an accidental topology loop could cause a data packet loop and disrupt switch and network operation.

This procedure is optional.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree portfast edge bpdupfilter default</b> <b>Example:</b> Device(config)# <b>spanning-tree portfast edge bpdupfilter default</b>	Globally enables BPDU filtering. By default, BPDU filtering is disabled.
<b>Step 4</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/2</b>	Specifies the interface connected to an end station, and enters interface configuration mode.
<b>Step 5</b>	<b>spanning-tree portfast edge</b> <b>Example:</b> Device(config-if)# <b>spanning-tree portfast edge</b>	Enables the PortFast edge feature on the specified interface.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

## Enabling UplinkFast for Use with Redundant Links (CLI)



**Note** When you enable UplinkFast, it affects all VLANs on the switch or switch stack. You cannot configure UplinkFast on an individual VLAN.

You can configure the UplinkFast or the Cross-Stack UplinkFast (CSUF) feature for Rapid PVST+ or for the MSTP, but the feature remains disabled (inactive) until you change the spanning-tree mode to PVST+.

This procedure is optional. Follow these steps to enable UplinkFast and CSUF.

### Before you begin

UplinkFast cannot be enabled on VLANs that have been configured with a switch priority. To enable UplinkFast on a VLAN with switch priority configured, first restore the switch priority on the VLAN to the default value using the **no spanning-tree vlan *vlan-id* priority** global configuration command.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree uplinkfast [max-update-rate pkts-per-second]</b> <b>Example:</b> Device(config)# <b>spanning-tree uplinkfast max-update-rate 200</b>	Enables UplinkFast. (Optional) For <i>pkts-per-second</i> , the range is 0 to 32000 packets per second; the default is 150. If you set the rate to 0, station-learning frames are not generated, and the spanning-tree topology converges more slowly after a loss of connectivity. When you enter this command, CSUF also is enabled on all nonstack port interfaces.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.



When UplinkFast is enabled, the switch priority of all VLANs is set to 49152. If you change the path cost to a value less than 3000 and you enable UplinkFast or UplinkFast is already enabled, the path cost of all interfaces and VLAN trunks is increased by 3000 (if you change the path cost to 3000 or above, the path cost is not altered). The changes to the switch priority and the path cost reduce the chance that a switch will become the root switch.

When UplinkFast is disabled, the switch priorities of all VLANs and path costs of all interfaces are set to default values if you did not modify them from their defaults.

When you enable the UplinkFast feature using these instructions, CSUF is automatically globally enabled on nonstack port interfaces.

## Disabling UplinkFast (CLI)

This procedure is optional.

Follow these steps to disable UplinkFast and Cross-Stack UplinkFast (CSUF).

### Before you begin

UplinkFast must be enabled.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>no spanning-tree uplinkfast</b> <b>Example:</b>  Device(config)# <b>no spanning-tree uplinkfast</b>	Disables UplinkFast and CSUF on the switch and all of its VLANs.
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.

When UplinkFast is disabled, the switch priorities of all VLANs and path costs of all interfaces are set to default values if you did not modify them from their defaults.

When you disable the UplinkFast feature using these instructions, CSUF is automatically globally disabled on nonstack port interfaces.

## Enabling BackboneFast (CLI)

You can enable BackboneFast to detect indirect link failures and to start the spanning-tree reconfiguration sooner.

You can configure the BackboneFast feature for Rapid PVST+ or for the MSTP, but the feature remains disabled (inactive) until you change the spanning-tree mode to PVST+.

This procedure is optional. Follow these steps to enable BackboneFast on the switch.

### Before you begin

If you use BackboneFast, you must enable it on all switches in the network. BackboneFast is not supported on Token Ring VLANs. This feature is supported for use with third-party switches.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree backbonefast</b> <b>Example:</b> Device(config)# <b>spanning-tree backbonefast</b>	Enables BackboneFast.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Enabling EtherChannel Guard (CLI)

You can enable EtherChannel guard to detect an EtherChannel misconfiguration if your device is running PVST+, Rapid PVST+, or MSTP.

This procedure is optional.

Follow these steps to enable EtherChannel Guard on the device.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree etherchannel guard misconfig</b> <b>Example:</b> Device(config)# <b>spanning-tree etherchannel guard misconfig</b>	Enables EtherChannel guard.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

### What to do next

You can use the **show interfaces status err-disabled** privileged EXEC command to show which device ports are disabled because of an EtherChannel misconfiguration. On the remote device, you can enter the **show etherchannel summary** privileged EXEC command to verify the EtherChannel configuration.

After the configuration is corrected, enter the **shutdown** and **no shutdown** interface configuration commands on the port-channel interfaces that were misconfigured.

## Enabling Root Guard (CLI)

Root guard enabled on an interface applies to all the VLANs to which the interface belongs. Do not enable the root guard on interfaces to be used by the UplinkFast feature. With UplinkFast, the backup interfaces (in the blocked state) replace the root port in the case of a failure. However, if root guard is also enabled, all the backup interfaces used by the UplinkFast feature are placed in the root-inconsistent state (blocked) and are prevented from reaching the forwarding state.



**Note** You cannot enable both root guard and loop guard at the same time.

You can enable this feature if your switch is running PVST+, Rapid PVST+, or MSTP.

This procedure is optional.

Follow these steps to enable root guard on the switch.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/2</b>	Specifies an interface to configure, and enters interface configuration mode.
<b>Step 4</b>	<b>spanning-tree guard root</b> <b>Example:</b> Device(config-if)# <b>spanning-tree guard root</b>	Enables root guard on the interface. By default, root guard is disabled on all interfaces.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

## Enabling Loop Guard (CLI)

You can use loop guard to prevent alternate or root ports from becoming designated ports because of a failure that leads to a unidirectional link. This feature is most effective when it is configured on the entire switched network. Loop guard operates only on interfaces that are considered point-to-point by the spanning tree.



**Note** You cannot enable both loop guard and root guard at the same time.

You can enable this feature if your device is running PVST+, Rapid PVST+, or MSTP.

This procedure is optional. Follow these steps to enable loop guard on the device.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	Enter one of the following commands: <ul style="list-style-type: none"> <li>• <code>show spanning-tree active</code></li> <li>• <code>show spanning-tree mst</code></li> </ul> <b>Example:</b>  Device# <code>show spanning-tree active</code>  or  Device# <code>show spanning-tree mst</code>	Verifies which interfaces are alternate or root ports.
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>spanning-tree loopguard default</b>  <b>Example:</b>  Device(config)# <code>spanning-tree loopguard default</code>	Enables loop guard.  By default, loop guard is disabled.
<b>Step 4</b>	<b>end</b>  <b>Example:</b>  Device(config)# <code>end</code>	Returns to privileged EXEC mode.

## Monitoring the Spanning-Tree Status

*Table 59: Commands for Monitoring the Spanning-Tree Status*

Command	Purpose
<code>show spanning-tree active</code>	Displays spanning-tree information on active interfaces only.

Command	Purpose
<code>show spanning-tree detail</code>	Displays a detailed summary of interface information.
<code>show spanning-tree interface <i>interface-id</i></code>	Displays spanning-tree information for the specified interface.
<code>show spanning-tree mst interface <i>interface-id</i></code>	Displays MST information for the specified interface.
<code>show spanning-tree summary [totals]</code>	Displays a summary of interface states or displays the total lines of the spanning-tree state section.
<code>show spanning-tree mst interface <i>interface-id</i> portfast edge</code>	Displays spanning-tree portfast information for the specified interface.

## Additional References for Optional Spanning Tree Features

### Related Documents

Related Topic	Document Title
Spanning tree protocol commands	LAN Switching Command Reference, Cisco IOS XE Release 3SE ( Catalyst 3850 Switches).

### Standards and RFCs

Standard/RFC	Title
None	—

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for Optional Spanning-Tree Features

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.







## CHAPTER 47

# Configuring EtherChannels

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- [Information About EtherChannels, on page 803](#)
- [How to Configure EtherChannels, on page 816](#)
- [Monitoring EtherChannel, PAgP, and LACP Status, on page 831](#)
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## Restrictions for EtherChannels

The following are restrictions for EtherChannels:

- All ports in an EtherChannel must be assigned to the same VLAN or they must be configured as trunk ports.
- Layer 3 EtherChannels are not supported if running the LAN Base license feature set.
- You cannot have a switch stack containing a mix of Catalyst 3850 and Catalyst 3650 switches.

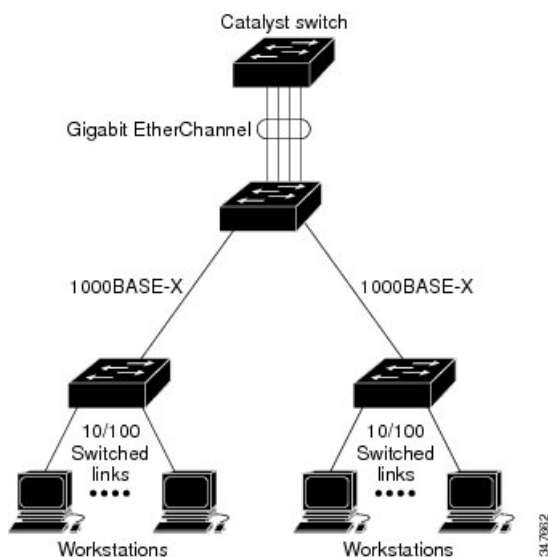
## Information About EtherChannels

### EtherChannel Overview

EtherChannel provides fault-tolerant high-speed links between switches, routers, and servers. You can use the EtherChannel to increase the bandwidth between the wiring closets and the data center, and you can deploy it anywhere in the network where bottlenecks are likely to occur. EtherChannel provides automatic recovery for the loss of a link by redistributing the load across the remaining links. If a link fails, EtherChannel redirects traffic from the failed link to the remaining links in the channel without intervention.

An EtherChannel consists of individual Ethernet links bundled into a single logical link.

Figure 62: Typical EtherChannel Configuration



Each EtherChannel can consist of up to eight compatibly configured Ethernet ports.

The number of EtherChannels is limited to 128.

The LAN Base feature set supports up to 24 EtherChannels.

All ports in each EtherChannel must be configured as either Layer 2 or Layer 3 ports. The EtherChannel Layer 3 ports are made up of routed ports. Routed ports are physical ports configured to be in Layer 3 mode by using the **no switchport** interface configuration command. For more information, see the Configuring Interface Characteristics chapter.

## EtherChannel Modes

You can configure an EtherChannel in one of these modes: Port Aggregation Protocol (PAgP), Link Aggregation Control Protocol (LACP), or On. Configure both ends of the EtherChannel in the same mode:

- When you configure one end of an EtherChannel in either PAgP or LACP mode, the system negotiates with the other end of the channel to determine which ports should become active. If the remote port cannot negotiate an EtherChannel, the local port is put into an independent state and continues to carry data traffic as would any other single link. The port configuration does not change, but the port does not participate in the EtherChannel.
- When you configure an EtherChannel in the **on** mode, no negotiations take place. The switch forces all compatible ports to become active in the EtherChannel. The other end of the channel (on the other switch) must also be configured in the **on** mode; otherwise, packet loss can occur.

## EtherChannel on Devices

You can create an EtherChannel on a device, on a single device in the stack, or on multiple devices in the stack (known as cross-stack EtherChannel).

Figure 63: Single-Switch EtherChannel

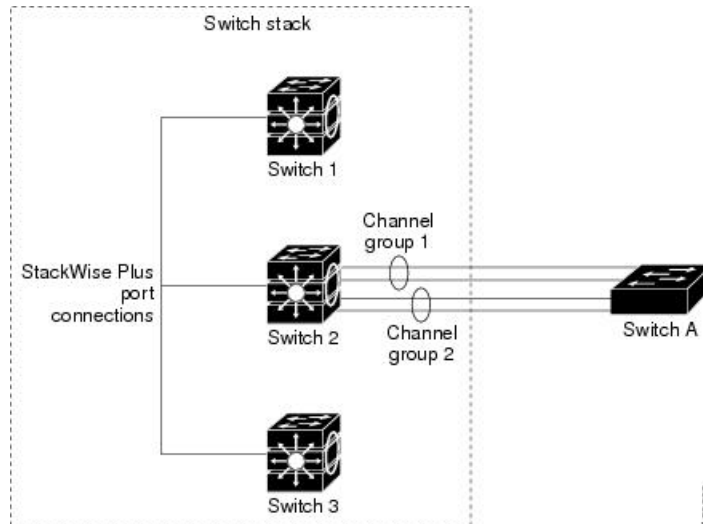
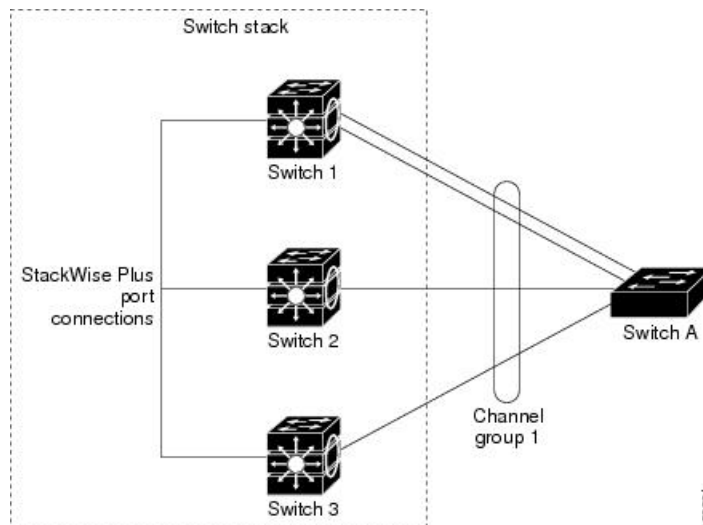


Figure 64: Cross-Stack EtherChannel



## EtherChannel Link Failover

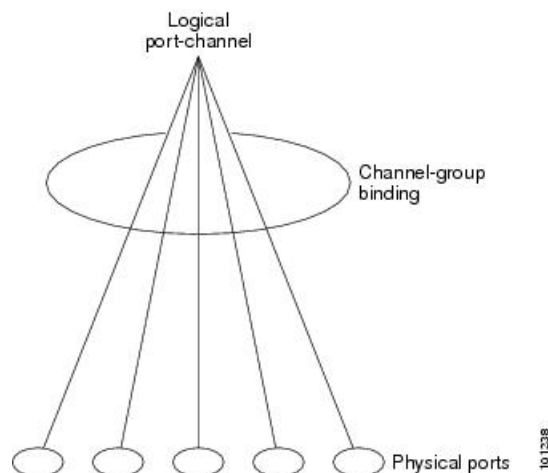
If a link within an EtherChannel fails, traffic previously carried over that failed link moves to the remaining links within the EtherChannel. If traps are enabled on the switch, a trap is sent for a failure that identifies the switch, the EtherChannel, and the failed link. Inbound broadcast and multicast packets on one link in an EtherChannel are blocked from returning on any other link of the EtherChannel.

## Channel Groups and Port-Channel Interfaces

An EtherChannel comprises a channel group and a port-channel interface. The channel group binds physical ports to the port-channel interface. Configuration changes applied to the port-channel interface apply to all the physical ports bound together in the channel group.

**Figure 65: Relationship of Physical Ports, Channel Group and Port-Channel Interface**

The **channel-group** command binds the physical port and the port-channel interface together. Each EtherChannel has a port-channel logical interface numbered from 1 to 128. This port-channel interface number corresponds to the one specified with the **channel-group** interface configuration command.



- With Layer 2 ports, use the **channel-group** interface configuration command to dynamically create the port-channel interface.

You also can use the **interface port-channel port-channel-number** global configuration command to manually create the port-channel interface, but then you must use the **channel-group channel-group-number** command to bind the logical interface to a physical port. The *channel-group-number* can be the same as the *port-channel-number*; or you can use a new number. If you use a new number, the **channel-group** command dynamically creates a new port channel.

- With Layer 3 ports, you should manually create the logical interface by using the **interface port-channel** global configuration command followed by the **no switchport** interface configuration command. You then manually assign an interface to the EtherChannel by using the **channel-group** interface configuration command.
- With Layer 3 ports, use the **no switchport** interface command to configure the interface as a Layer 3 interface, and then use the **channel-group** interface configuration command to dynamically create the port-channel interface.

## Port Aggregation Protocol

The Port Aggregation Protocol (PAgP) is a Cisco-proprietary protocol that can be run only on Cisco devices and on those devices licensed by vendors to support PAgP. PAgP facilitates the automatic creation of EtherChannels by exchanging PAgP packets between Ethernet ports. PAgP can be enabled on cross-stack EtherChannels.

By using PAgP, the device or device stack learns the identity of partners capable of supporting PAgP and the capabilities of each port. It then dynamically groups similarly configured ports (on a single device in the stack) into a single logical link (channel or aggregate port). Similarly configured ports are grouped based on hardware, administrative, and port parameter constraints. For example, PAgP groups the ports with the same speed, duplex mode, native VLAN, VLAN range, and trunking status and type. After grouping the links into an EtherChannel, PAgP adds the group to the spanning tree as a single device port.

## PAgP Modes

PAgP modes specify whether a port can send PAgP packets, which start PAgP negotiations, or only respond to PAgP packets received.

**Table 60: EtherChannel PAgP Modes**

Mode	Description
<b>auto</b>	Places a port into a passive negotiating state, in which the port responds to PAgP packets it receives but does not start PAgP packet negotiation. This setting minimizes the transmission of PAgP packets.
<b>desirable</b>	Places a port into an active negotiating state, in which the port starts negotiations with other ports by sending PAgP packets. This mode is supported when the EtherChannel members are from different switches in the switch stack (cross-stack EtherChannel).

Switch ports exchange PAgP packets only with partner ports configured in the **auto** or **desirable** modes. Ports configured in the **on** mode do not exchange PAgP packets.

Both the **auto** and **desirable** modes enable ports to negotiate with partner ports to form an EtherChannel based on criteria such as port speed, and for Layer 2 EtherChannels, based on trunk state and VLAN numbers.

Ports can form an EtherChannel when they are in different PAgP modes as long as the modes are compatible. For example:

- A port in the **desirable** mode can form an EtherChannel with another port that is in the **desirable** or **auto** mode.
- A port in the **auto** mode can form an EtherChannel with another port in the **desirable** mode.

A port in the **auto** mode cannot form an EtherChannel with another port that is also in the **auto** mode because neither port starts PAgP negotiation.

### Silent Mode

If your switch is connected to a partner that is PAgP-capable, you can configure the switch port for nonsilent operation by using the **non-silent** keyword. If you do not specify **non-silent** with the **auto** or **desirable** mode, silent mode is assumed.

Use the silent mode when the switch is connected to a device that is not PAgP-capable and seldom, if ever, sends packets. An example of a silent partner is a file server or a packet analyzer that is not generating traffic. In this case, running PAgP on a physical port connected to a silent partner prevents that switch port from ever becoming operational. However, the silent setting allows PAgP to operate, to attach the port to a channel group, and to use the port for transmission.

## PAgP Learn Method and Priority

Network devices are classified as PAgP physical learners or aggregate-port learners. A device is a physical learner if it learns addresses by physical ports and directs transmissions based on that knowledge. A device is an aggregate-port learner if it learns addresses by aggregate (logical) ports. The learn method must be configured the same at both ends of the link.

When a device and its partner are both aggregate-port learners, they learn the address on the logical port-channel. The device sends packets to the source by using any of the ports in the EtherChannel. With aggregate-port learning, it is not important on which physical port the packet arrives.

PAgP cannot automatically detect when the partner device is a physical learner and when the local device is an aggregate-port learner. Therefore, you must manually set the learning method on the local device to learn addresses by physical ports. You also must set the load-distribution method to source-based distribution, so that any given source MAC address is always sent on the same physical port.

You also can configure a single port within the group for all transmissions and use other ports for hot-standby. The unused ports in the group can be swapped into operation in just a few seconds if the selected single port loses hardware-signal detection. You can configure which port is always selected for packet transmission by changing its priority with the **pagp port-priority** interface configuration command. The higher the priority, the more likely that the port will be selected.



**Note** The device supports address learning only on aggregate ports even though the **physical-port** keyword is provided in the CLI. The **pagp learn-method** command and the **pagp port-priority** command have no effect on the device hardware, but they are required for PAgP interoperability with devices that only support address learning by physical ports, such as the Catalyst 1900 switch.

When the link partner of the device is a physical learner, we recommend that you configure the device as a physical-port learner by using the **pagp learn-method physical-port** interface configuration command. Set the load-distribution method based on the source MAC address by using the **port-channel load-balance src-mac** global configuration command. The device then sends packets to the physical learner using the same port in the EtherChannel from which it learned the source address. Only use the **pagp learn-method** command in this situation.

## PAgP Interaction with Other Features

The Dynamic Trunking Protocol (DTP) and the Cisco Discovery Protocol (CDP) send and receive packets over the physical ports in the EtherChannel. Trunk ports send and receive PAgP protocol data units (PDUs) on the lowest numbered VLAN.

In Layer 2 EtherChannels, the first port in the channel that comes up provides its MAC address to the EtherChannel. If this port is removed from the bundle, one of the remaining ports in the bundle provides its MAC address to the EtherChannel. For Layer 3 EtherChannels, the MAC address is allocated by the active device as soon as the interface is created (through the **interface port-channel** global configuration command).

PAgP sends and receives PAgP PDUs only from ports that are up and have PAgP enabled for the auto or desirable mode.

## Link Aggregation Control Protocol

The LACP is defined in IEEE 802.3ad and enables Cisco devices to manage Ethernet channels between devices that conform to the IEEE 802.3ad protocol. LACP facilitates the automatic creation of EtherChannels by exchanging LACP packets between Ethernet ports.

By using LACP, the device or device stack learns the identity of partners capable of supporting LACP and the capabilities of each port. It then dynamically groups similarly configured ports into a single logical link (channel or aggregate port). Similarly configured ports are grouped based on hardware, administrative, and port parameter constraints. For example, LACP groups the ports with the same speed, duplex mode, native VLAN, VLAN range, and trunking status and type. After grouping the links into an EtherChannel, LACP adds the group to the spanning tree as a single device port.

The independent mode behavior of ports in a port channel is changed. With CSCtn96950, by default, standalone mode is enabled. When no response is received from an LACP peer, ports in the port channel are moved to suspended state.

## LACP Modes

LACP modes specify whether a port can send LACP packets or only receive LACP packets.

**Table 61: EtherChannel LACP Modes**

Mode	Description
<b>active</b>	Places a port into an active negotiating state in which the port starts negotiations with other ports by sending LACP packets.
<b>passive</b>	Places a port into a passive negotiating state in which the port responds to LACP packets that it receives, but does not start LACP packet negotiation. This setting minimizes the transmission of LACP packets.

Both the **active** and **passive LACP** modes enable ports to negotiate with partner ports to an EtherChannel based on criteria such as port speed, and for Layer 2 EtherChannels, based on trunk state and VLAN numbers.

Ports can form an EtherChannel when they are in different LACP modes as long as the modes are compatible. For example:

- A port in the **active** mode can form an EtherChannel with another port that is in the **active** or **passive** mode.
- A port in the **passive** mode cannot form an EtherChannel with another port that is also in the **passive** mode because neither port starts LACP negotiation.

## LACP and Link Redundancy

LACP port-channel operation, bandwidth availability, and link redundancy can be further refined with the LACP port-channel min-links and the LACP max-bundle features.

The LACP port-channel min-links feature:

- Configures the minimum number of ports that must be linked up and bundled in the LACP port channel.
- Prevents a low-bandwidth LACP port channel from becoming active.
- Causes an LACP port channel to become inactive if there are too few active members ports to supply the required minimum bandwidth.

The LACP max-bundle feature:

- Defines an upper limit on the number of bundled ports in an LACP port channel.
- Allows hot-standby ports with fewer bundled ports. For example, in an LACP port channel with five ports, you can specify a max-bundle of three, and the two remaining ports are designated as hot-standby ports.

## LACP Interaction with Other Features

The DTP and the CDP send and receive packets over the physical ports in the EtherChannel. Trunk ports send and receive LACP PDUs on the lowest numbered VLAN.

In Layer 2 EtherChannels, the first port in the channel that comes up provides its MAC address to the EtherChannel. If this port is removed from the bundle, one of the remaining ports in the bundle provides its MAC address to the EtherChannel. For Layer 3 EtherChannels, the MAC address is allocated by the active device as soon as the interface is created through the **interface port-channel** global configuration command.

LACP sends and receives LACP PDUs only from ports that are up and have LACP enabled for the active or passive mode.

## EtherChannel On Mode

EtherChannel **on** mode can be used to manually configure an EtherChannel. The **on** mode forces a port to join an EtherChannel without negotiations. The **on** mode can be useful if the remote device does not support PAgP or LACP. In the **on** mode, a usable EtherChannel exists only when the devices at both ends of the link are configured in the **on** mode.

Ports that are configured in the **on** mode in the same channel group must have compatible port characteristics, such as speed and duplex. Ports that are not compatible are suspended, even though they are configured in the **on** mode.



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**Caution**

You should use care when using the **on** mode. This is a manual configuration, and ports on both ends of the EtherChannel must have the same configuration. If the group is misconfigured, packet loss or spanning-tree loops can occur.

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## Load-Balancing and Forwarding Methods

EtherChannel balances the traffic load across the links in a channel by reducing part of the binary pattern formed from the addresses in the frame to a numerical value that selects one of the links in the channel. You can specify one of several different load-balancing modes, including load distribution based on MAC addresses, IP addresses, source addresses, destination addresses, or both source and destination addresses. The selected mode applies to all EtherChannels configured on the device.



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**Note**

Layer 3 Equal-cost multi path (ECMP) load balancing is based on source IP address, destination IP address, source port, destination port, and layer 4 protocol. Fragmented packets will be treated on two different links based on the algorithm calculated using these parameters. Any changes in one of these parameters will result in load balancing.

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You configure the load-balancing and forwarding method by using the **port-channel load-balance** and the **port-channel load-balance extended** global configuration commands.

## MAC Address Forwarding

With source-MAC address forwarding, when packets are forwarded to an EtherChannel, they are distributed across the ports in the channel based on the source-MAC address of the incoming packet. Therefore, to provide



load-balancing, packets from different hosts use different ports in the channel, but packets from the same host use the same port in the channel.

With destination-MAC address forwarding, when packets are forwarded to an EtherChannel, they are distributed across the ports in the channel based on the destination host's MAC address of the incoming packet. Therefore, packets to the same destination are forwarded over the same port, and packets to a different destination are sent on a different port in the channel.

With source-and-destination MAC address forwarding, when packets are forwarded to an EtherChannel, they are distributed across the ports in the channel based on both the source and destination MAC addresses. This forwarding method, a combination source-MAC and destination-MAC address forwarding methods of load distribution, can be used if it is not clear whether source-MAC or destination-MAC address forwarding is better suited on a particular device. With source-and-destination MAC-address forwarding, packets sent from host A to host B, host A to host C, and host C to host B could all use different ports in the channel.

## IP Address Forwarding

With source-IP address-based forwarding, packets are distributed across the ports in the EtherChannel based on the source-IP address of the incoming packet. To provide load balancing, packets from different IP addresses use different ports in the channel, and packets from the same IP address use the same port in the channel.

With destination-IP address-based forwarding, packets are distributed across the ports in the EtherChannel based on the destination-IP address of the incoming packet. To provide load balancing, packets from the same IP source address sent to different IP destination addresses could be sent on different ports in the channel. Packets sent from different source IP addresses to the same destination IP address are always sent on the same port in the channel.

With source-and-destination IP address-based forwarding, packets are distributed across the ports in the EtherChannel based on both the source and destination IP addresses of the incoming packet. This forwarding method, a combination of source-IP and destination-IP address-based forwarding, can be used if it is not clear whether source-IP or destination-IP address-based forwarding is better suited on a particular device. In this method, packets sent from the IP address A to IP address B, from IP address A to IP address C, and from IP address C to IP address B could all use different ports in the channel.

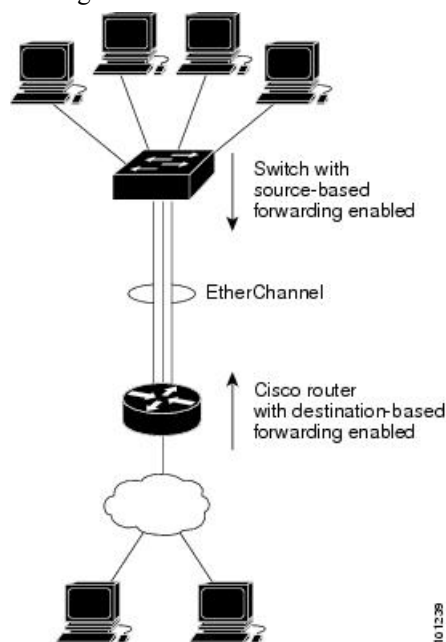
## Load-Balancing Advantages

Different load-balancing methods have different advantages, and the choice of a particular load-balancing method should be based on the position of the device in the network and the kind of traffic that needs to be load-distributed.

### *Figure 66: Load Distribution and Forwarding Methods*

In the following figure, an EtherChannel of four workstations communicates with a router. Because the router is a single MAC-address device, source-based forwarding on the device EtherChannel ensures that the device uses all available bandwidth to the router. The router is configured for destination-based forwarding because

the large number of workstations ensures that the traffic is evenly distributed from the router EtherChannel.



Use the option that provides the greatest variety in your configuration. For example, if the traffic on a channel is going only to a single MAC address, using the destination-MAC address always chooses the same link in the channel. Using source addresses or IP addresses might result in better load-balancing.

## EtherChannel and Device Stacks

If a stack member that has ports participating in an EtherChannel fails or leaves the stack, the active device removes the failed stack member device ports from the EtherChannel. The remaining ports of the EtherChannel, if any, continue to provide connectivity.

When a device is added to an existing stack, the new device receives the running configuration from the active device and updates itself with the EtherChannel-related stack configuration. The stack member also receives the operational information (the list of ports that are up and are members of a channel).

When two stacks merge that have EtherChannels configured between them, self-looped ports result. Spanning tree detects this condition and acts accordingly. Any PAgP or LACP configuration on a winning device stack is not affected, but the PAgP or LACP configuration on the losing device stack is lost after the stack reboots.

## Device Stack and PAgP

With PAgP, if the active device fails or leaves the stack, the standby device becomes the new active device. A spanning-tree reconvergence is not triggered unless there is a change in the EtherChannel bandwidth. The new active device synchronizes the configuration of the stack members to that of the active device. The PAgP configuration is not affected after an active device change unless the EtherChannel has ports residing on the old active device.

## Device Stacks and LACP

With LACP, the system ID uses the stack MAC address from the active device. When an active device fails or leaves the stack and the standby device becomes the new active device change, the LACP system ID is unchanged. By default, the LACP configuration is not affected after the active device changes.

## Default EtherChannel Configuration

The default EtherChannel configuration is described in this table.

**Table 62: Default EtherChannel Configuration**

Feature	Default Setting
Channel groups	None assigned.
Port-channel logical interface	None defined.
PAgP mode	No default.
PAgP learn method	Aggregate-port learning on all ports.
PAgP priority	128 on all ports.
LACP mode	No default.
LACP learn method	Aggregate-port learning on all ports.
LACP port priority	32768 on all ports.
LACP system priority	32768.
LACP system ID	LACP system priority and the device or stack MAC address.
Load-balancing	Load distribution on the device is based on the source-MAC address of the incoming packet.

## EtherChannel Configuration Guidelines

If improperly configured, some EtherChannel ports are automatically disabled to avoid network loops and other problems. Follow these guidelines to avoid configuration problems:

- Do not try to configure more than 128 EtherChannels on the device or device stack.
- Configure a PAgP EtherChannel with up to eight Ethernet ports of the same type.
- Configure a LACP EtherChannel with up to 16 Ethernet ports of the same type. Up to eight ports can be active, and up to eight ports can be in standby mode.
- Configure all ports in an EtherChannel to operate at the same speeds and duplex modes.

- Enable all ports in an EtherChannel. A port in an EtherChannel that is disabled by using the **shutdown** interface configuration command is treated as a link failure, and its traffic is transferred to one of the remaining ports in the EtherChannel.
- When a group is first created, all ports follow the parameters set for the first port to be added to the group. If you change the configuration of one of these parameters, you must also make the changes to all ports in the group:
  - Allowed-VLAN list
  - Spanning-tree path cost for each VLAN
  - Spanning-tree port priority for each VLAN
  - Spanning-tree Port Fast setting
- Do not configure a port to be a member of more than one EtherChannel group.
- Do not configure an EtherChannel in both the PAgP and LACP modes. EtherChannel groups running PAgP and LACP can coexist on the same device or on different devices in the stack. Individual EtherChannel groups can run either PAgP or LACP, but they cannot interoperate.
- Do not configure a secure port as part of an EtherChannel or the reverse.
- Do not configure a port that is an active or a not-yet-active member of an EtherChannel as an IEEE 802.1x port. If you try to enable IEEE 802.1x on an EtherChannel port, an error message appears, and IEEE 802.1x is not enabled.
- If EtherChannels are configured on device interfaces, remove the EtherChannel configuration from the interfaces before globally enabling IEEE 802.1x on a device by using the **dot1x system-auth-control** global configuration command.
- If cross-stack EtherChannel is configured and the device stack partitions, loops and forwarding issues can occur.

## Layer 2 EtherChannel Configuration Guidelines

When configuring Layer 2 EtherChannels, follow these guidelines:

- Assign all ports in the EtherChannel to the same VLAN, or configure them as trunks. Ports with different native VLANs cannot form an EtherChannel.
- An EtherChannel supports the same allowed range of VLANs on all the ports in a trunking Layer 2 EtherChannel. If the allowed range of VLANs is not the same, the ports do not form an EtherChannel even when PAgP is set to the **auto** or **desirable** mode.
- Ports with different spanning-tree path costs can form an EtherChannel if they are otherwise compatibly configured. Setting different spanning-tree path costs does not, by itself, make ports incompatible for the formation of an EtherChannel.

## Layer 3 EtherChannel Configuration Guidelines

- For Layer 3 EtherChannels, assign the Layer 3 address to the port-channel logical interface, not to the physical ports in the channel.

## Auto-LAG

The auto-LAG feature provides the ability to auto create EtherChannels on ports connected to a switch. By default, auto-LAG is disabled globally and is enabled on all port interfaces. The auto-LAG applies to a switch only when it is enabled globally.

On enabling auto-LAG globally, the following scenarios are possible:

- All port interfaces participate in creation of auto EtherChannels provided the partner port interfaces have EtherChannel configured on them. For more information, see the *"The supported auto-LAG configurations between the actor and partner devices"* table below.
- Ports that are already part of manual EtherChannels cannot participate in creation of auto EtherChannels.
- When auto-LAG is disabled on a port interface that is already a part of an auto created EtherChannel, the port interface will unbundle from the auto EtherChannel.

The following table shows the supported auto-LAG configurations between the actor and partner devices:

**Table 63: The supported auto-LAG configurations between the actor and partner devices**

Actor/Partner	Active	Passive	Auto
Active	Yes	Yes	Yes
Passive	Yes	No	Yes
Auto	Yes	Yes	Yes

On disabling auto-LAG globally, all auto created Etherchannels become manual EtherChannels.

You cannot add any configurations in an existing auto created EtherChannel. To add, you should first convert it into a manual EtherChannel by executing the **port-channel**<channel-number>**persistent**.



**Note** Auto-LAG uses the LACP protocol to create auto EtherChannel. Only one EtherChannel can be automatically created with the unique partner devices.

## Auto-LAG Configuration Guidelines

Follow these guidelines when configuring the auto-LAG feature.

- When auto-LAG is enabled globally and on the port interface , and if you do not want the port interface to become a member of the auto EtherChannel, disable the auto-LAG on the port interface.
- A port interface will not bundle to an auto EtherChannel when it is already a member of a manual EtherChannel. To allow it to bundle with the auto EtherChannel, first unbundle the manual EtherChannel on the port interface.
- When auto-LAG is enabled and auto EtherChannel is created, you can create multiple EtherChannels manually with the same partner device. But by default, the port tries to create auto EtherChannel with the partner device.
- The auto-LAG is supported only on Layer 2 EtherChannel. It is not supported on Layer 3 interface and Layer 3 EtherChannel.

- The auto-LAG is supported on cross-stack EtherChannel.

## How to Configure EtherChannels

After you configure an EtherChannel, configuration changes applied to the port-channel interface apply to all the physical ports assigned to the port-channel interface, and configuration changes applied to the physical port affect only the port where you apply the configuration.

### Configuring Layer 2 EtherChannels (CLI)

You configure Layer 2 EtherChannels by assigning ports to a channel group with the **channel-group** interface configuration command. This command automatically creates the port-channel logical interface.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet</b>	Specifies a physical port, and enters interface configuration mode. Valid interfaces are physical ports. For a PAgP EtherChannel, you can configure up to eight ports of the same type and speed for the same group. For a LACP EtherChannel, you can configure up to 16 Ethernet ports of the same type. Up to eight ports can be active, and up to eight ports can be in standby mode.
<b>Step 3</b>	<b>switchport mode {access   trunk}</b> <b>Example:</b> Device(config-if)# <b>switchport mode access</b>	Assigns all ports as static-access ports in the same VLAN, or configure them as trunks. If you configure the port as a static-access port, assign it to only one VLAN. The range is 1 to 4094.
<b>Step 4</b>	<b>switchport access vlan <i>vlan-id</i></b> <b>Example:</b> Device(config-if)# <b>switchport access vlan 22</b>	(Optional) If you configure the port as a static-access port, assign it to only one VLAN. The range is 1 to 4094.

	Command or Action	Purpose
Step 5	<p><b>channel-group</b> <i>channel-group-number</i> <b>mode</b> {<b>auto</b> [<b>non-silent</b>]   <b>desirable</b> [<b>non-silent</b>]   <b>on</b> }   { <b>active</b>   <b>passive</b> }</p> <p><b>Example:</b></p> <pre>Device(config-if)# channel-group 5 mode auto</pre>	<p>Assigns the port to a channel group, and specifies the PAgP or the LACP mode.</p> <p>For <i>channel-group-number</i>, the range is 1 to 128.</p> <p>For <b>mode</b>, select one of these keywords:</p> <ul style="list-style-type: none"> <li>• <b>auto</b>—Enables PAgP only if a PAgP device is detected. It places the port into a passive negotiating state, in which the port responds to PAgP packets it receives but does not start PAgP packet negotiation. This keyword is not supported when EtherChannel members are from different devices in the device stack.</li> <li>• <b>desirable</b>—Unconditionally enables PAgP. It places the port into an active negotiating state, in which the port starts negotiations with other ports by sending PAgP packets. This keyword is not supported when EtherChannel members are from different devices in the device stack.</li> <li>• <b>on</b>—Forces the port to channel without PAgP or LACP. In the <b>on</b> mode, an EtherChannel exists only when a port group in the <b>on</b> mode is connected to another port group in the <b>on</b> mode.</li> <li>• <b>non-silent</b>—(Optional) If your device is connected to a partner that is PAgP-capable, configures the device port for nonsilent operation when the port is in the <b>auto</b> or <b>desirable</b> mode. If you do not specify <b>non-silent</b>, silent is assumed. The silent setting is for connections to file servers or packet analyzers. This setting allows PAgP to operate, to attach the port to a channel group, and to use the port for transmission.</li> <li>• <b>active</b>—Enables LACP only if a LACP device is detected. It places the port into an active negotiating state in which the port starts negotiations with other ports by sending LACP packets.</li> <li>• <b>passive</b>—Enables LACP on the port and places it into a passive negotiating state in which the port responds to LACP packets</li> </ul>

	Command or Action	Purpose
		that it receives, but does not start LACP packet negotiation.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config-if) # <b>end</b>	Returns to privileged EXEC mode.

## Configuring Layer 3 EtherChannels (CLI)

Follow these steps to assign an Ethernet port to a Layer 3 EtherChannel. This procedure is required.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/2</b>	Specifies a physical port, and enters interface configuration mode. Valid interfaces include physical ports. For a PAGP EtherChannel, you can configure up to eight ports of the same type and speed for the same group. For a LACP EtherChannel, you can configure up to 16 Ethernet ports of the same type. Up to eight ports can be active, and up to eight ports can be in standby mode.
<b>Step 4</b>	<b>no ip address</b> <b>Example:</b> Device(config-if) # <b>no ip address</b>	Ensures that there is no IP address assigned to the physical port.



	Command or Action	Purpose
<b>Step 5</b>	<b>no switchport</b> <b>Example:</b> <pre>Device(config-if)# no switchport</pre>	Puts the port into Layer 3 mode.
<b>Step 6</b>	<b>channel-group <i>channel-group-number</i> mode</b> <b>{ auto [ non-silent ]   desirable [ non-silent ]   on }   { active   passive }</b> <b>Example:</b> <pre>Device(config-if)# channel-group 5 mode auto</pre>	<p>Assigns the port to a channel group, and specifies the PAgP or the LACP mode.</p> <p>For <b>mode</b>, select one of these keywords:</p> <ul style="list-style-type: none"> <li>• <b>auto</b>—Enables PAgP only if a PAgP device is detected. It places the port into a passive negotiating state, in which the port responds to PAgP packets it receives but does not start PAgP packet negotiation. This keyword is not supported when EtherChannel members are from different devices in the device stack.</li> <li>• <b>desirable</b>—Unconditionally enables PAgP. It places the port into an active negotiating state, in which the port starts negotiations with other ports by sending PAgP packets. This keyword is not supported when EtherChannel members are from different devices in the device stack.</li> <li>• <b>on</b>—Forces the port to channel without PAgP or LACP. In the <b>on</b> mode, an EtherChannel exists only when a port group in the <b>on</b> mode is connected to another port group in the <b>on</b> mode.</li> <li>• <b>non-silent</b>—(Optional) If your device is connected to a partner that is PAgP capable, configures the device port for nonsilent operation when the port is in the <b>auto</b> or <b>desirable</b> mode. If you do not specify <b>non-silent</b>, silent is assumed. The silent setting is for connections to file servers or packet analyzers. This setting allows PAgP to operate, to attach the port to a channel group, and to use the port for transmission.</li> <li>• <b>active</b>—Enables LACP only if a LACP device is detected. It places the port into an active negotiating state in which the port starts negotiations with other ports by sending LACP packets.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>passive</b>—Enables LACP on the port and places it into a passive negotiating state in which the port responds to LACP packets that it receives, but does not start LACP packet negotiation.</li> </ul>
<b>Step 7</b>	<b>end</b> <b>Example:</b> <pre>Device(config-if) # end</pre>	Returns to privileged EXEC mode.

## Configuring EtherChannel Load-Balancing (CLI)

You can configure EtherChannel load-balancing to use one of several different forwarding methods.

This task is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<b>port-channel load-balance { dst-ip   dst-mac   dst-mixed-ip-port   dst-port   extended [dst-ip   dst-mac   dst-port   ipv6-label   l3-protocol   src-ip   src-mac   src-port ]   src-dst-ip   src-dst-mac src-dst-mixed-ip-port src-dst-portsrc-ip   src-mac   src-mixed-ip-port   src-port }</b> <b>Example:</b> <pre>Device(config)# port-channel load-balance src-mac</pre>	Configures an EtherChannel load-balancing method. The default is <b>src-mac</b> . Select one of these load-distribution methods: <ul style="list-style-type: none"> <li>• <b>dst-ip</b>—Specifies destination-host IP address.</li> <li>• <b>dst-mac</b>—Specifies the destination-host MAC address of the incoming packet.</li> <li>• <b>dst-mixed-ip-port</b>—Specifies the host IP address and TCP/UDP port.</li> <li>• <b>dst-port</b>—Specifies the destination TCP/UDP port.</li> <li>• <b>extended</b>—Specifies extended load balance methods--combinations of source and destination methods beyond those available with the standard command.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>ipv6-label</b>—Specifies the IPv6 flow label.</li> <li>• <b>l3-proto</b>—Specifies the Layer 3 protocol.</li> <li>• <b>src-dst-ip</b>—Specifies the source and destination host IP address.</li> <li>• <b>src-dst-mac</b>—Specifies the source and destination host MAC address.</li> <li>• <b>src-dst-mixed-ip-port</b>—Specifies the source and destination host IP address and TCP/UDP port.</li> <li>• <b>src-dst-port</b>—Specifies the source and destination TCP/UDP port.</li> <li>• <b>src-ip</b>—Specifies the source host IP address.</li> <li>• <b>src-mac</b>—Specifies the source MAC address of the incoming packet.</li> <li>• <b>src-mixed-ip-port</b>—Specifies the source host IP address and TCP/UDP port.</li> <li>• <b>src-port</b>—Specifies the source TCP/UDP port.</li> </ul>
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring EtherChannel Extended Load-Balancing (CLI)

Configure EtherChannel extended load-balancing when you want to use a combination of load-balancing methods.

This task is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<p><b>port-channel load-balance extended</b> [ <b>dst-ip</b>   <b>dst-mac</b> <b>dst-port</b>   <b>ipv6-label</b>   <b>l3-proto</b>   <b>src-ip</b>   <b>src-mac</b>   <b>src-port</b> ]</p> <p><b>Example:</b></p> <pre>Device(config)# port-channel load-balance extended dst-ip dst-mac src-ip</pre>	<p>Configures an EtherChannel extended load-balancing method.</p> <p>The default is <b>src-mac</b>.</p> <p>Select one of these load-distribution methods:</p> <ul style="list-style-type: none"> <li>• <b>dst-ip</b>—Specifies destination-host IP address.</li> <li>• <b>dst-mac</b>—Specifies the destination-host MAC address of the incoming packet.</li> <li>• <b>dst-port</b>—Specifies the destination TCP/UDP port.</li> <li>• <b>ipv6-label</b>—Specifies the IPv6 flow label.</li> <li>• <b>l3-proto</b>—Specifies the Layer 3 protocol.</li> <li>• <b>src-ip</b>—Specifies the source host IP address.</li> <li>• <b>src-mac</b>—Specifies the source MAC address of the incoming packet.</li> <li>• <b>src-port</b>—Specifies the source TCP/UDP port.</li> </ul>
<b>Step 3</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.

## Configuring the PAgP Learn Method and Priority (CLI)

This task is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<p><b>interface</b> <i>interface-id</i></p> <p><b>Example:</b></p>	Specifies the port for transmission, and enters interface configuration mode.

	Command or Action	Purpose
	Device(config)# <b>interface</b> gigabitethernet	
<b>Step 3</b>	<p><b>pagp learn-method physical-port</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# pagp learn-method physical port</pre>	<p>Selects the PAgP learning method.</p> <p>By default, <b>aggregation-port learning</b> is selected, which means the device sends packets to the source by using any of the ports in the EtherChannel. With aggregate-port learning, it is not important on which physical port the packet arrives.</p> <p>Selects <b>physical-port</b> to connect with another device that is a physical learner.</p> <p>Make sure to configure the <b>port-channel load-balance</b> global configuration command to <b>src-mac</b>.</p> <p>The learning method must be configured the same at both ends of the link.</p>
<b>Step 4</b>	<p><b>pagp port-priority</b> <i>priority</i></p> <p><b>Example:</b></p> <pre>Device(config-if)# pagp port-priority 200</pre>	<p>Assigns a priority so that the selected port is chosen for packet transmission.</p> <p>For <i>priority</i>, the range is 0 to 255. The default is 128. The higher the priority, the more likely that the port will be used for PAgP transmission.</p>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# end</pre>	<p>Returns to privileged EXEC mode.</p>

## Configuring LACP Hot-Standby Ports

When LACP is enabled, the software, by default, tries to configure the maximum number of LACP-compatible ports in a channel, up to a maximum of 16 ports. Only eight LACP links can be active at one time; the remaining eight links are placed in hot-standby mode. If one of the active links becomes inactive, a link that is in the hot-standby mode becomes active in its place.

You can override the default behavior by specifying the maximum number of active ports in a channel, in which case, the remaining ports become hot-standby ports. For example, if you specify a maximum of five ports in a channel, up to 11 ports become hot-standby ports.

If you configure more than eight links for an EtherChannel group, the software automatically decides which of the hot-standby ports to make active based on the LACP priority. To every link between systems that operate LACP, the software assigns a unique priority made up of these elements (in priority order):

- LACP system priority

- System ID (the device MAC address)
- LACP port priority
- Port number

In priority comparisons, numerically lower values have higher priority. The priority decides which ports should be put in standby mode when there is a hardware limitation that prevents all compatible ports from aggregating.

Determining which ports are active and which are hot standby is a two-step procedure. First the system with a numerically lower system priority and system ID is placed in charge of the decision. Next, that system decides which ports are active and which are hot standby, based on its values for port priority and port number. The port priority and port number values for the other system are not used.

You can change the default values of the LACP system priority and the LACP port priority to affect how the software selects active and standby links.

## Configuring the LACP Max Bundle Feature (CLI)

When you specify the maximum number of bundled LACP ports allowed in a port channel, the remaining ports in the port channel are designated as hot-standby ports.

Beginning in privileged EXEC mode, follow these steps to configure the maximum number of LACP ports in a port channel. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface port-channel</b> <i>channel-number</i> <b>Example:</b> Device(config)# <b>interface port-channel</b> <b>2</b>	Enters interface configuration mode for a port channel.  The range is 1 to 128.
<b>Step 3</b>	<b>lACP max-bundle</b> <i>max-bundle-number</i> <b>Example:</b> Device(config-if)# <b>lACP max-bundle</b> <b>3</b>	Specifies the maximum number of LACP ports in the port-channel bundle.  The range is 1 to 8.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring LACP Port-Channel Standalone Disable

To disable the standalone EtherChannel member port state on a port channel, perform this task on the port channel interface:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface port-channel <i>channel-group</i></b> <b>Example:</b> Device(config)# <b>interface port-channel <i>channel-group</i></b>	Selects a port channel interface to configure.
<b>Step 3</b>	<b>port-channel standalone-disable</b> <b>Example:</b> Device(config-if)# <b>port-channel standalone-disable</b>	Disables the standalone mode on the port-channel interface.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Exits configuration mode.
<b>Step 5</b>	<b>show etherchannel</b> <b>Example:</b>  Device# <b>show etherchannel <i>channel-group</i></b> <b>port-channel</b> Device# <b>show etherchannel <i>channel-group</i></b> <b>detail</b>	Verifies the configuration.

## Configuring the LACP Port Channel Min-Links Feature (CLI)

You can specify the minimum number of active ports that must be in the link-up state and bundled in an EtherChannel for the port channel interface to transition to the link-up state. Using EtherChannel min-links, you can prevent low-bandwidth LACP EtherChannels from becoming active. Port channel min-links also cause LACP EtherChannels to become inactive if they have too few active member ports to supply the required minimum bandwidth.

To configure the minimum number of links that are required for a port channel. Perform the following tasks.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface port-channel <i>channel-number</i></b> <b>Example:</b>  Device(config)# <b>interface port-channel</b> <b>2</b>	Enters interface configuration mode for a port-channel.  For <i>channel-number</i> , the range is 1 to 63.
<b>Step 4</b>	<b>port-channel min-links <i>min-links-number</i></b> <b>Example:</b>  Device(config-if)# <b>port-channel min-links</b> <b>3</b>	Specifies the minimum number of member ports that must be in the link-up state and bundled in the EtherChannel for the port channel interface to transition to the link-up state.  For <i>min-links-number</i> , the range is 2 to 8.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.

**Configuring the LACP System Priority (CLI)**

You can configure the system priority for all the EtherChannels that are enabled for LACP by using the **lACP system-priority** global configuration command. You cannot configure a system priority for each LACP-configured channel. By changing this value from the default, you can affect how the software selects active and standby links.

You can use the **show etherchannel summary** privileged EXEC command to see which ports are in the hot-standby mode (denoted with an H port-state flag).

Follow these steps to configure the LACP system priority. This procedure is optional.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b>	Enables privileged EXEC mode.



	Command or Action	Purpose
	<b>Example:</b>  Device> <b>enable</b>	<ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>lACP system-priority <i>priority</i></b>  <b>Example:</b>  Device(config)# <b>lACP system-priority 32000</b>	Configures the LACP system priority.  The range is 1 to 65535. The default is 32768.  The lower the value, the higher the system priority.
<b>Step 4</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring the LACP Port Priority (CLI)

By default, all ports use the same port priority. If the local system has a lower value for the system priority and the system ID than the remote system, you can affect which of the hot-standby links become active first by changing the port priority of LACP EtherChannel ports to a lower value than the default. The hot-standby ports that have lower port numbers become active in the channel first. You can use the **show etherchannel summary** privileged EXEC command to see which ports are in the hot-standby mode (denoted with an H port-state flag).



**Note** If LACP is not able to aggregate all the ports that are compatible (for example, the remote system might have more restrictive hardware limitations), all the ports that cannot be actively included in the EtherChannel are put in the hot-standby state and are used only if one of the channeled ports fails.

Follow these steps to configure the LACP port priority. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device(config)# <b>interface gigabitethernet</b>	Specifies the port to be configured, and enters interface configuration mode.
<b>Step 4</b>	<b>lACP port-priority <i>priority</i></b> <b>Example:</b>  Device(config-if)# <b>lACP port-priority 32000</b>	Configures the LACP port priority.  The range is 1 to 65535. The default is 32768. The lower the value, the more likely that the port will be used for LACP transmission.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring LACP Fast Rate Timer

You can change the LACP timer rate to modify the duration of the LACP timeout. Use the **lACP rate** command to set the rate at which LACP control packets are received by an LACP-supported interface. You can change the timeout rate from the default rate (30 seconds) to the fast rate (1 second). This command is supported only on LACP-enabled interfaces.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 3</b>	<b>interface</b> { <code>fastethernet</code>   <code>gigabitethernet</code>   <code>tengigabitethernet</code> } <i>slot/port</i> <b>Example:</b> Device(config)# <code>interface gigabitEthernet 2/1</code>	Configures an interface and enters interface configuration mode.
<b>Step 4</b>	<b>lacp rate</b> { <code>normal</code>   <code>fast</code> } <b>Example:</b> Device(config-if)# <code>lacp rate fast</code>	Configures the rate at which LACP control packets are received by an LACP-supported interface. <ul style="list-style-type: none"> <li>• To reset the timeout rate to its default, use the <b>no lacp rate</b> command.</li> </ul>
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show lacp internal</b> <b>Example:</b> Device# <code>show lacp internal</code> Device# <code>show lacp counters</code>	Verifies your configuration.

## Configuring Auto-LAG Globally

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>[no] port-channel auto</b> <b>Example:</b> Device(config)# <b>port-channel auto</b>	Enables the auto-LAG feature on a switch globally. Use the no form of this command to disable the auto-LAG feature on the switch globally.  <b>Note</b> By default, the auto-LAG feature is enabled on the port.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show etherchannel auto</b> <b>Example:</b> Device# <b>show etherchannel auto</b>	Displays that EtherChannel is created automatically.

## Configuring Auto-LAG on a Port Interface

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet</b>	Specifies the port interface to be enabled for auto-LAG, and enters interface configuration mode.
<b>Step 4</b>	<b>[no] channel-group auto</b> <b>Example:</b> Device(config-if)# <b>channel-group auto</b>	(Optional) Enables auto-LAG feature on individual port interface. Use the no form of this command to disable the auto-LAG feature on individual port interface.  <b>Note</b> By default, the auto-LAG feature is enabled on the port.

	Command or Action	Purpose
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show etherchannel auto</b> <b>Example:</b> Device# <b>show etherchannel auto</b>	Displays that EtherChannel is created automatically.

### What to do next

## Configuring Persistence with Auto-LAG

You use the persistence command to convert the auto created EtherChannel into a manual one and allow you to add configuration on the existing EtherChannel.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>port-channel <i>channel-number</i> persistent</b> <b>Example:</b> Device# <b>port-channel 1 persistent</b>	Converts the auto created EtherChannel into a manual one and allows you to add configuration on the EtherChannel.
<b>Step 3</b>	<b>show etherchannel summary</b> <b>Example:</b> Device# <b>show etherchannel summary</b>	Displays the EtherChannel information.

## Monitoring EtherChannel, PAgP, and LACP Status

You can display EtherChannel, PAgP, and LACP status using the commands listed in this table.

*Table 64: Commands for Monitoring EtherChannel, PAgP, and LACP Status*

Command	Description
<b>clear lacp</b> { <i>channel-group-number</i> <b>counters</b>   <b>counters</b> }	Clears LACP channel-group information and traffic counters.

Command	Description
<b>clear pagp</b> { <i>channel-group-number</i> <b>counters</b>   <b>counters</b> }	Clears PAgP channel-group information and traffic counters.
<b>show etherchannel</b> [ <i>channel-group-number</i> { <b>detail</b>   <b>load-balance</b>   <b>port</b>   <b>port-channel</b>   <b>protocol</b>   <b>summary</b> } ] [ <b>detail</b>   <b>load-balance</b>   <b>port</b>   <b>port-channel</b>   <b>protocol</b>   <b>auto</b>   <b>summary</b> ]	Displays EtherChannel information in a brief, detailed, and one-line summary form. Also displays the load-balance or frame-distribution scheme, port, port-channel, protocol, and Auto-LAG information.
<b>show pagp</b> [ <i>channel-group-number</i> ] { <b>counters</b>   <b>internal</b>   <b>neighbor</b> }	Displays PAgP information such as traffic information, the internal PAgP configuration, and neighbor information.
<b>show pagp</b> [ <i>channel-group-number</i> ] <b>dual-active</b>	Displays the dual-active detection status.
<b>show lacp</b> [ <i>channel-group-number</i> ] { <b>counters</b>   <b>internal</b>   <b>neighbor</b>   <b>sys-id</b> }	Displays LACP information such as traffic information, the internal LACP configuration, and neighbor information.
<b>show running-config</b>	Verifies your configuration entries.
<b>show etherchannel load-balance</b>	Displays the load balance or frame distribution scheme among ports in the port channel.

## Configuration Examples for Configuring EtherChannels

### Configuring Layer 2 EtherChannels: Examples

This example shows how to configure an EtherChannel on a single device in the stack. It assigns two ports as static-access ports in VLAN 10 to channel 5 with the PAgP mode **desirable**:

```
Device# configure terminal
Device(config)# interface range gigabitethernet -2
Device(config-if-range)# switchport mode access
Device(config-if-range)# switchport access vlan 10
Device(config-if-range)# channel-group 5 mode desirable non-silent
Device(config-if-range)# end
```

This example shows how to configure an EtherChannel on a single device in the stack. It assigns two ports as static-access ports in VLAN 10 to channel 5 with the LACP mode **active**:

```
Device# configure terminal
Device(config)# interface range gigabitethernet -2
Device(config-if-range)# switchport mode access
Device(config-if-range)# switchport access vlan 10
Device(config-if-range)# channel-group 5 mode active
Device(config-if-range)# end
```

This example shows how to configure a cross-stack EtherChannel. It uses LACP passive mode and assigns two ports on stack member 1 and one port on stack member 2 as static-access ports in VLAN 10 to channel 5:

```
Device# configure terminal
Device(config)# interface range gigabitethernet -5
Device(config-if-range)# switchport mode access
Device(config-if-range)# switchport access vlan 10
Device(config-if-range)# channel-group 5 mode passive
Device(config-if-range)# exit
Device(config)# interface gigabitethernet
Device(config-if)# switchport mode access
Device(config-if)# switchport access vlan 10
Device(config-if)# channel-group 5 mode passive
Device(config-if)# exit
```

PoE or LACP negotiation errors may occur if you configure two ports from switch to the access point (AP). This scenario can be avoided if the port channel configuration is on the switch side. For more details, see the following example:

```
interface Port-channel1
  switchport access vlan 20
  switchport mode access
  switchport nonegotiate
  no port-channel standalone-disable <--this one
  spanning-tree portfast
```



**Note** If the port reports LACP errors on port flap, you should include the following command as well: **no errdisable detect cause pagp-flap**

## Configuring Layer 3 EtherChannels: Examples

This example shows how to configure a Layer 3 EtherChannel. It assigns two ports to channel 5 with the LACP mode **active**:

```
Device# configure terminal
Device(config)# interface range gigabitethernet2/0/1 -2
Device(config-if-range)# no ip address
Device(config-if-range)# no switchport
Device(config-if-range)# channel-group 5 mode active
Device(config-if-range)# end
```

This example shows how to configure a cross-stack Layer 3 EtherChannel. It assigns two ports on stack member 2 and one port on stack member 3 to channel 7 using LACP active mode:

```
Device# configure terminal
Device(config)# interface range gigabitethernet2/0/4 -5
Device(config-if-range)# no ip address
```

```

Device(config-if-range)# no switchport
Device(config-if-range)# channel-group 7 mode active
Device(config-if-range)# exit
Device(config)# interface gigabitethernet3/0/3
Device(config-if)# no ip address
Device(config-if)# no switchport
Device(config-if)# channel-group 7 mode active
Device(config-if)# exit

```

## Configuring LACP Hot-Standby Ports: Example

This example shows how to configure an Etherchannel (port channel 2) that will be active when there are at least three active ports, will comprise up to seven active ports and the remaining ports (up to nine) as hot-standby ports :

```

Device# configure terminal
Device(config)# interface port-channel 2
Device(config-if)# port-channel min-links 3
Device(config-if)# lacp max-bundle 7

```

This example shows how to disable the standalone EtherChannel member port state on port channel 42:

```

Device(config)# interface port-channel channel-group
Device(config-if)# port-channel standalone-disable

```

This example shows how to verify the configuration:

```

Device# show etherchannel 42 port-channel | include Standalone
Standalone Disable = enabled
Device# show etherchannel 42 detail | include Standalone
Standalone Disable = enabled

```

## Configuring Auto LAG: Examples

This example shows how to configure Auto-LAG on a switch

```

device> enable
device# configure terminal
device (config)# port-channel auto
device (config-if)# end
device# show etherchannel auto

```

The following example shows the summary of EtherChannel that was created automatically.

```

device# show etherchannel auto
Flags: D - down          P - bundled in port-channel
       I - stand-alone  s - suspended
       H - Hot-standby (LACP only)
       R - Layer3       S - Layer2
       U - in use       f - failed to allocate aggregator
       M - not in use, minimum links not met
       u - unsuitable for bundling
       w - waiting to be aggregated
       d - default port
       A - formed by Auto LAG

```



```
Number of channel-groups in use: 1
Number of aggregators:          1
```

```
Group  Port-channel  Protocol  Ports
-----+-----+-----+-----
1      Po1(SUA)          LACP     Gi1/0/45(P) Gi2/0/21(P) Gi3/0/21(P)
```

The following example shows the summary of auto EtherChannel after executing the **port-channel 1 persistent** command.

```
device# port-channel 1 persistent
```

```
device# show etherchannel summary
Switch# show etherchannel summary
Flags: D - down          P - bundled in port-channel
       I - stand-alone  s - suspended
       H - Hot-standby (LACP only)
       R - Layer3        S - Layer2
       U - in use        f - failed to allocate aggregator
       M - not in use, minimum links not met
       u - unsuitable for bundling
       w - waiting to be aggregated
       d - default port
       A - formed by Auto LAG
```

```
Number of channel-groups in use: 1
Number of aggregators:          1
```

```
Group  Port-channel  Protocol  Ports
-----+-----+-----+-----
1      Po1(SU)          LACP     Gi1/0/45(P) Gi2/0/21(P) Gi3/0/21(P)
```

## Additional References for EtherChannels

### Related Documents

Related Topic	Document Title
Layer 2 command reference	<i>Layer 2/3 Command Reference (Catalyst 3850 Switches)</i>

### Standards and RFCs

Standard/RFC	Title
None	—

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

**Feature Information for EtherChannels**

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.
Cisco IOS XE 3.3SE	Support for the LACP max-bundle feature and the port channel min-links features was added.
Cisco IOS 15.2(3)E2, Cisco IOS XE 3.7.2E	Auto-LAG feature was introduced.



# CHAPTER 48

## Configuring Resilient Ethernet Protocol

- [Overview of Resilient Ethernet Protocol, on page 837](#)
- [How to Configure Resilient Ethernet Protocol, on page 842](#)
- [Monitoring Resilient Ethernet Protocol Configurations, on page 850](#)

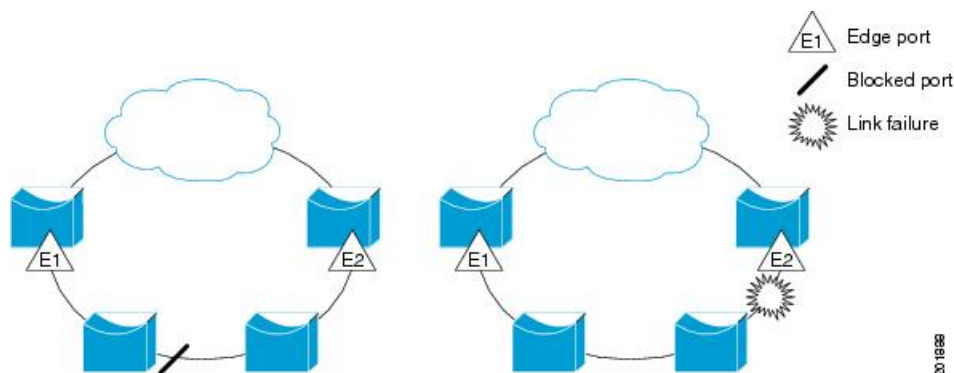
### Overview of Resilient Ethernet Protocol

Resilient Ethernet Protocol (REP) is a Cisco-proprietary protocol that provides an alternative to Spanning Tree Protocol (STP) to control network loops, handle link failures, and improve convergence time. REP controls a group of ports connected in a segment, ensures that the segment does not create any bridging loops, and responds to link failures within the segment. REP provides a basis for constructing more complex networks and supports VLAN load balancing.

A REP segment is a chain of ports connected to each other and configured with a segment ID. Each segment consists of standard (nonedge) segment ports and two user-configured edge ports. A device can have no more than two ports that belong to the same segment, and each segment port can have only one external neighbor. A segment can go through a shared medium, but on any link, only two ports can belong to the same segment. REP is supported only on Trunk Ethernet Flow Point (EFP) interfaces.

The following figure shows an example of a segment consisting of six ports spread across four switches. Ports E1 and E2 are configured as edge ports. When all the ports are operational (as in the segment on the left), a single port is blocked, as shown by the diagonal line. When there is a failure in the network, the blocked port returns to the forwarding state to minimize network disruption.

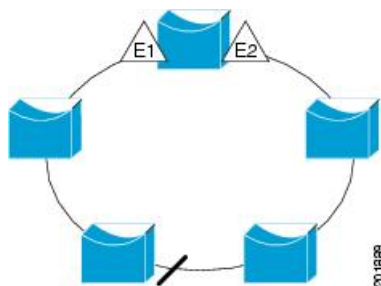
**Figure 67: REP Open Segment**



The segment shown in the figure above is an open segment; there is no connectivity between the two edge ports. The REP segment cannot cause a bridging loop, and you can safely connect the segment edges to any network. All the hosts connected to devices inside the segment have two possible connections to the rest of the network through the edge ports, but only one connection is accessible at any time. If a failure occurs on any segment or on any port on a REP segment, REP unblocks all the ports to ensure that connectivity is available through the other gateway.

The segment shown in the following figure is a ring segment, with both the edge ports located on the same device. With this configuration, you can create a redundant connection between any two devices in the segment.

**Figure 68: REP Ring Segment**



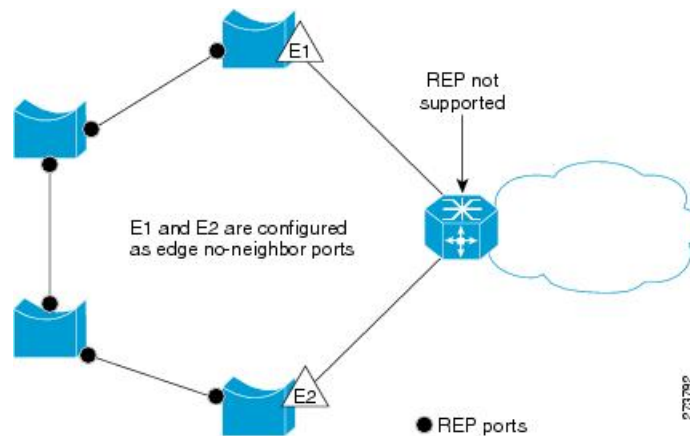
REP segments have the following characteristics:

- If all the ports in a segment are operational, one port (referred to as the *alternate* port) is in the blocked state for each VLAN. If VLAN load balancing is configured, two ports in the segment control the blocked state of VLANs.
- If one or more ports in a segment is not operational, and cause a link failure, all the ports forward traffic on all the VLANs to ensure connectivity.
- In case of a link failure, alternate ports are unblocked as quickly as possible. When the failed link is up, a logically blocked port per VLAN is selected with minimal disruption to the network.

You can construct almost any type of network based on REP segments. REP also supports VLAN load balancing, which is controlled by the primary edge port (any port in the segment).

In access ring-topologies, the neighboring switch might not support REP as shown in the following figure. In this scenario, you can configure the non-REP-facing ports (E1 and E2) as edge no-neighbor ports. These ports inherit all the properties of edge ports, and you can configure them the same as any edge port, including configuring them to send STP or REP topology change notices to the aggregation switch. In this scenario, the STP topology change notice (TCN) that is sent is a multiple spanning-tree (MST) STP message.

Figure 69: Edge No-Neighbor Ports



REP has these limitations:

- You must configure each segment port; an incorrect configuration might cause forwarding loops in the networks.
- REP can manage only a single failed port within the segment; multiple port failures within the REP segment cause loss of network connectivity.
- You should configure REP only in networks with redundancy. Configuring REP in a network without redundancy causes loss of connectivity.

## Link Integrity

REP does not use an end-to-end polling function between edge ports to verify link integrity. It implements local link failure detection. The REP Link Status Layer (LSL) detects its REP-aware neighbor and establishes connectivity within the segment. All the VLANs are blocked on an interface until the neighbor is detected. After the neighbor is identified, REP determines which neighbor port should become the alternate port and which ports should forward traffic.

Each port in a segment has a unique port ID. The port ID format is similar to that used by the spanning tree algorithm: a port number (unique on the bridge) associated to a MAC address (unique in the network). When a segment port is coming up, its LSL starts sending packets that include the segment ID and the port ID. The port is declared as operational after it performs a three-way handshake with a neighbor in the same segment.

A segment port does not become operational if:

- No neighbor has the same segment ID.
- More than one neighbor has the same segment ID.
- A neighbor does not acknowledge a local port as a peer.

Each port creates an adjacency with its immediate neighbor. After the neighbor adjacencies are created, the ports negotiate with each other to determine the blocked port for the segment, which will function as the alternate port. All the other ports become unblocked. By default, REP packets are sent to a bridge protocol data unit-class MAC address. The packets can also be sent to a Cisco multicast address, which is used only to send blocked port advertisement (BPA) messages when there is a failure in the segment. The packets are dropped by the devices not running REP.

## Fast Convergence

REP runs on a physical link basis and not on a per-VLAN basis. Only one hello message is required for all the VLANs, and this reduces the load on the protocol. We recommend that you create VLANs consistently on all the switches in a given segment and configure the same allowed VLANs on the REP trunk ports. To avoid the delay introduced by relaying messages in software, REP also allows some packets to be flooded to a regular multicast address. These messages operate at the hardware flood layer (HFL) and are flooded to the entire network, not just the REP segment. Switches that do not belong to the segment treat them as data traffic. You can control flooding of these messages by configuring an administrative VLAN for the entire domain or for a particular segment.

The estimated convergence recovery time is between 150-500ms upto 1000 MACs, 5 VLANs. The estimated convergence recovery time for multicast traffic is between 300-500ms upto 100Groups and 5 VLANs.

## VLAN Load Balancing

One edge port in the REP segment acts as the primary edge port; and another as the secondary edge port. It is the primary edge port that always participates in VLAN load balancing in the segment. REP VLAN balancing is achieved by blocking some VLANs at a configured alternate port and all the other VLANs at the primary edge port. When you configure VLAN load balancing, you can specify the alternate port in one of three ways:

- By entering the port ID of the interface. To identify the port ID of a port in the segment, enter the **show interface rep detail** interface configuration command for the port.
- By entering the **preferred** keyword to select the port that you previously configured as the preferred alternate port with the **rep segment segment-id preferred** interface configuration command.
- By entering the neighbor offset number of a port in the segment, which identifies the downstream neighbor port of an edge port. The neighbor offset number range is  $-256$  to  $+256$ ; a value of 0 is invalid. The primary edge port has an offset number of 1; positive numbers above 1 identify downstream neighbors of the primary edge port. Negative numbers indicate the secondary edge port (offset number -1) and its downstream neighbors.



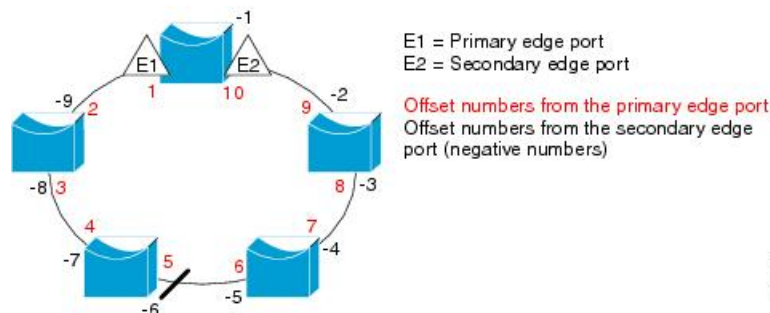

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**Note** Configure offset numbers on the primary edge port by identifying a port's downstream position from the primary (or secondary) edge port. Never enter an offset value of 1 because that is the offset number of the primary edge port.

---

The following figure shows neighbor offset numbers for a segment, where E1 is the primary edge port and E2 is the secondary edge port. The red numbers inside the ring are numbers offset from the primary edge port; the black numbers outside of the ring show the offset numbers from the secondary edge port. Note that you can identify all the ports (except the primary edge port) by either a positive offset number (downstream position from the primary edge port) or a negative offset number (downstream position from the secondary edge port). If E2 became the primary edge port, its offset number would then be 1 and E1 would be -1.

Figure 70: Neighbor Offset Numbers in a Segment



When the REP segment is complete, all the VLANs are blocked. When you configure VLAN load balancing, you must also configure triggers in one of two ways:

- Manually trigger VLAN load balancing at any time by entering the **rep preempt segment** *segment-id* privileged EXEC command on the switch that has the primary edge port.
- Configure a preempt delay time by entering the **rep preempt delay** *seconds* interface configuration command. After a link failure and recovery, VLAN load balancing begins after the configured preemption time period elapses. Note that the delay timer restarts if another port fails before the time has elapsed.



**Note** When VLAN load balancing is configured, it does not start working until triggered by either manual intervention or a link failure and recovery.

When VLAN load balancing is triggered, the primary edge port sends out a message to alert all the interfaces in the segment about the preemption. When the secondary port receives the message, the message is sent to the network to notify the alternate port to block the set of VLANs specified in the message and to notify the primary edge port to block the remaining VLANs.

You can also configure a particular port in the segment to block all the VLANs. Only the primary edge port initiates VLAN load balancing, which is not possible if the segment is not terminated by an edge port on each end. The primary edge port determines the local VLAN load-balancing configuration.

Reconfigure the primary edge port to reconfigure load balancing. When you change the load-balancing configuration, the primary edge port waits for the **rep preempt segment** command or for the configured preempt delay period after a port failure and recovery, before executing the new configuration. If you change an edge port to a regular segment port, the existing VLAN load-balancing status does not change. Configuring a new edge port might cause a new topology configuration.

## Spanning Tree Interaction

REP does not interact with the STP or the Flex Link feature, but can coexist with both. A port that belongs to a segment is removed from spanning tree control, and STP BPDUs are not accepted or sent from segment ports. Therefore, STP cannot run on a segment.

To migrate from an STP ring configuration to an REP segment configuration, begin by configuring a single port in the ring as part of the segment and continue by configuring contiguous ports to minimize the number of segments. Since each segment always contains a blocked port, multiple segments means multiple blocked

ports and a potential loss of connectivity. After the segment is configured in both directions up to the location of the edge ports, configure the edge ports.

## REP Ports

REP segments consist of Failed, Open, or Alternate ports:

- A port configured as a regular segment port starts as a failed port.
- After the neighbor adjacencies are determined, the port transitions to alternate port state, blocking all the VLANs on the interface. Blocked-port negotiations occur, and when the segment settles, one blocked port remains in the alternate role and all the other ports become open ports.
- When a failure occurs in a link, all the ports move to the Failed state. When the Alternate port receives the failure notification, it changes to the Open state, forwarding all the VLANs.

A regular segment port converted to an edge port, or an edge port converted to a regular segment port, does not always result in a topology change. If you convert an edge port into a regular segment port, VLAN load balancing is not implemented unless it has been configured. For VLAN load balancing, you must configure two edge ports in the segment.

A segment port that is reconfigured as a spanning tree port restarts according to the spanning tree configuration. By default, this is a designated blocking port. If PortFast is configured or if STP is disabled, the port goes into the forwarding state.

## How to Configure Resilient Ethernet Protocol

A segment is a collection of ports connected to one another in a chain and configured with a segment ID. To configure REP segments, configure the REP administrative VLAN (or use the default VLAN 1) and then add the ports to the segment, using interface configuration mode. You should configure two edge ports in a segment, with one of them being the primary edge port and the other the secondary edge port by default. A segment should have only one primary edge port. If you configure two ports in a segment as primary edge ports, for example, ports on different switches, the REP selects one of them to serve as the segment's primary edge port. If required, you can configure the location to which segment topology change notices (STCNs) and VLAN load balancing are to be sent.

## Default REP Configuration

REP is disabled on all the interfaces. When enabled, the interface is a regular segment port unless it is configured as an edge port.

When REP is enabled, the task of sending segment topology change notices (STCNs) is disabled, all the VLANs are blocked, and the administrative VLAN is VLAN 1.

When VLAN load balancing is enabled, the default is manual preemption with the delay timer disabled. If VLAN load balancing is not configured, the default after manual preemption is to block all the VLANs in the primary edge port.

## REP Configuration Guidelines

Follow these guidelines when configuring REP:



- We recommend that you begin by configuring one port and then configure contiguous ports to minimize the number of segments and the number of blocked ports.
- If more than two ports in a segment fail when no external neighbors are configured, one port goes into a forwarding state for the data path to help maintain connectivity during configuration. In the **show rep interface** command output, the Port Role for this port is displayed as **Fail Logical Open**; the Port Role for the other failed port is displayed as **Fail No Ext Neighbor**. When the external neighbors for the failed ports are configured, the ports go through the alternate port transitions and eventually go to an open state, or remain as the alternate port, based on the alternate port selection mechanism.
- REP ports must be Layer 2 IEEE 802.1Q or Trunk ports.
- We recommend that you configure all the trunk ports in a segment with the same set of allowed VLANs.
- Be careful when configuring REP through a Telnet connection because REP blocks all the VLANs until another REP interface sends a message to unblock it. You might lose connectivity to the router if you enable REP in a Telnet session that accesses the router through the same interface.
- You cannot run REP and STP or REP and Flex Links on the same segment or interface.
- If you connect an STP network to an REP segment, be sure that the connection is at the segment edge. An STP connection that is not at the edge might cause a bridging loop because STP does not run on REP segments. All the STP BPDUs are dropped at REP interfaces.
- You must configure all the trunk ports in a segment with the same set of allowed VLANs. If this is not done, misconfiguration occurs.
- If REP is enabled on two ports on a switch, both the ports must be either regular segment ports or edge ports. REP ports follow these rules:
  - There is no limit to the number of REP ports on a switch. However, only two ports on a switch can belong to the same REP segment.
  - If only one port on a switch is configured in a segment, the port should be an edge port.
  - If two ports on a switch belong to the same segment, they must both be edge ports, regular segment ports, or one regular port and one edge no-neighbor port. An edge port and regular segment port on a switch cannot belong to the same segment.
  - If two ports on a switch belong to the same segment, and one is configured as an edge port and one as a regular segment port (a misconfiguration), the edge port is treated as a regular segment port.
- REP interfaces come up in a blocked state and remain in a blocked state until they are safe to be unblocked. You must, therefore, be aware of the status of REP interfaces to avoid sudden connection losses.
- REP sends all the LSL PDUs in the untagged frames to the native VLAN. The BPA message sent to a Cisco multicast address is sent to the administration VLAN, which is VLAN 1 by default.
- You can configure the duration for which a REP interface remains up without receiving a hello from a neighbor. Use the **rep lsl-age-timer** value interface configuration command to set the time from 120 ms to 10000 ms. The LSL hello timer is then set to the age-timer value divided by 3. In normal operation, three LSL hellos are sent before the age timer on the peer switch expires and checks for hello messages.
  - EtherChannel port channel interfaces do not support LSL age-timer values less than 1000 ms. If you try to configure a value less than 1000 ms on a port channel, you receive an error message and the command is rejected.

- REP ports cannot be configured as one of the following port types:
  - Switched Port Analyzer (SPAN) destination port
  - Tunnel port
  - Access port
- REP is supported on EtherChannels, but not on an individual port that belongs to an EtherChannel.
- There can be a maximum of 26 REP segments per switch.

## Configuring REP Administrative VLAN

To avoid the delay created by link-failure messages, and VLAN-blocking notifications during load balancing, REP floods packets to a regular multicast address at the hardware flood layer (HFL). These messages are flooded to the whole network, and not just the REP segment. You can control the flooding of these messages by configuring an administrative VLAN.

Follow these guidelines when configuring the REP administrative VLAN:

- If you do not configure an administrative VLAN, the default is VLAN 1.
- You can configure one admin VLAN on the switch for all segments.
- The administrative VLAN cannot be the RSPAN VLAN.

To configure the REP administrative VLAN, follow these steps, beginning in privileged EXEC mode:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>rep admin vlan <i>vlan-id</i></b> <b>Example:</b> Device(config)# <b>rep admin vlan 2</b>	Specifies the administrative VLAN. The range is from 2 to 4094.  To set the admin VLAN to 1, which is the default, enter the <b>no rep admin vlan</b> global configuration command.
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Exits global configuration mode and returns to privileged EXEC mode.
<b>Step 4</b>	<b>show interface [<i>interface-id</i>] rep detail</b> <b>Example:</b> Device# <b>show interface gigabitethernet1/1 rep detail</b>	(Optional) Verifies the configuration on a REP interface.

	Command or Action	Purpose
<b>Step 5</b>	<b>copy running-config startup config</b> <b>Example:</b> Device# <code>copy running-config startup config</code>	(Optional) Saves your entries in the switch startup configuration file.

## Configuring a REP Interface

To configure REP, enable REP on each segment interface and identify the segment ID. This task is mandatory, and must be done before other REP configurations. You must also configure a primary and secondary edge port on each segment. All the other steps are optional.

Follow these steps to enable and configure REP on an interface:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device# <code>interface gigabitethernet1/1</code>	Specifies the interface, and enters interface configuration mode. The interface can be a physical Layer 2 interface or a port channel (logical interface).
<b>Step 4</b>	<b>switchport mode trunk</b> <b>Example:</b> Device# <code>switchport mode trunk</code>	Configures the interface as a Layer 2 trunk port.
<b>Step 5</b>	<b>rep segment <i>segment-id</i> [edge [no-neighbor] [primary]] [preferred]</b> <b>Example:</b> Device# <code>rep segment 1 edge no-neighbor primary</code>	Enables REP on the interface and identifies a segment number. The segment ID range is from 1 to 1024. <p><b>Note</b> You must configure two edge ports, including one primary edge port, for each segment.</p> <p>These optional keywords are available:</p>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• (Optional) <b>edge</b>—Configures the port as an edge port. Each segment has only two edge ports. Entering the keyword <b>edge</b> without the keyword <b>primary</b> configures the port as the secondary edge port.</li> <li>• (Optional) <b>primary</b>—Configures the port as the primary edge port, the port on which you can configure VLAN load balancing.</li> <li>• (Optional) <b>no-neighbor</b>—Configures a port with no external REP neighbors as an edge port. The port inherits all the properties of an edge port, and you can configure the properties the same way you would for an edge port.</li> </ul> <p><b>Note</b> Although each segment can have only one primary edge port, if you configure edge ports on two different switches and enter the keyword <b>primary</b> on both the switches, the configuration is valid. However, REP selects only one of these ports as the segment primary edge port. You can identify the primary edge port for a segment by entering the <b>show rep topology</b> privileged EXEC command.</p> <ul style="list-style-type: none"> <li>• (Optional) <b>preferred</b>—Indicates that the port is the preferred alternate port or the preferred port for VLAN load balancing.</li> </ul> <p><b>Note</b> Configuring a port as preferred does not guarantee that it becomes the alternate port; it merely gives the port a slight edge over equal contenders. The alternate port is usually a previously failed port.</p>
<b>Step 6</b>	<p><b>rep stcn</b> {<i>interface interface id</i>   <b>segment id-list</b>   <b>stp</b>}</p> <p><b>Example:</b></p> <pre>Device# rep stcn segment 25-50</pre>	<p>(Optional) Configures the edge port to send segment topology change notices (STCNs).</p> <ul style="list-style-type: none"> <li>• <b>interface interface-id</b>—Designates a physical interface or port channel to receive STCNs.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>segment <i>id-list</i></b>—Identifies one or more segments to receive STCNs. The range is from 1 to 1024.</li> <li>• <b>stp</b>—Sends STCNs to STP networks.</li> </ul> <p><b>Note</b> Spanning Tree (MST) mode is required on edge no-neighbor nodes when <b>rep stcn stp</b> command is configured for sending STCNs to STP networks.</p>
<b>Step 7</b>	<p><b>rep block port</b> {<i>id port-id</i>   <i>neighbor-offset</i>   <b>preferred</b>} <b>vlan</b> {<i>vlan-list</i>   <b>all</b>}</p> <p><b>Example:</b></p> <pre>Device# rep block port id 0009001818D68700 vlan 1-100</pre>	<p>(Optional) Configures VLAN load balancing on the primary edge port, identifies the REP alternate port in one of three ways (<b>id <i>port-id</i></b>, <b><i>neighbor_offset</i></b>, <b>preferred</b>), and configures the VLANs to be blocked on the alternate port.</p> <ul style="list-style-type: none"> <li>• <b>id <i>port-id</i></b>—Identifies the alternate port by port ID. The port ID is automatically generated for each port in the segment. You can view interface port IDs by entering the <b>show interface type number rep [detail]</b> privileged EXEC command.</li> <li>• <b><i>neighbor_offset</i></b>—Number to identify the alternate port as a downstream neighbor from an edge port. The range is from -256 to 256, with negative numbers indicating the downstream neighbor from the secondary edge port. A value of <b>0</b> is invalid. Enter <b>-1</b> to identify the secondary edge port as the alternate port.</li> </ul> <p><b>Note</b> Because you enter the <b>rep block port</b> command at the primary edge port (offset number 1), you cannot enter an offset value of 1 to identify an alternate port.</p> <ul style="list-style-type: none"> <li>• <b>preferred</b>—Selects the regular segment port previously identified as the preferred alternate port for VLAN load balancing.</li> <li>• <b>vlan <i>vlan-list</i></b>—Blocks one VLAN or a range of VLANs.</li> <li>• <b>vlan all</b>—Blocks all the VLANs.</li> </ul> <p><b>Note</b> Enter this command only on the REP primary edge port.</p>

	Command or Action	Purpose
<b>Step 8</b>	<b>rep preempt delay</b> <i>seconds</i> <b>Example:</b> Device# <b>rep preempt delay 100</b>	(Optional) Configures a preempt time delay. <ul style="list-style-type: none"> <li>• Use this command if you want VLAN load balancing to be automatically triggered after a link failure and recovery.</li> <li>• The time delay range is between 15 to 300 seconds. The default is manual preemption with no time delay.</li> </ul> <b>Note</b> Enter this command only on the REP primary edge port.
<b>Step 9</b>	<b>rep lsl-age-timer</b> <i>value</i> <b>Example:</b> Device# <b>rep lsl-age-timer 2000</b>	(Optional) Configures a time (in milliseconds) for which the REP interface remains up without receiving a hello from a neighbor.  The range is from 120 to 10000 ms in 40-ms increments. The default is 5000 ms (5 seconds). <b>Note</b> <ul style="list-style-type: none"> <li>• EtherChannel port channel interfaces do not support LSL age-timer values that are less than 1000 ms.</li> <li>• Both the ports on the link should have the same LSL age configured in order to avoid link flaps.</li> </ul>
<b>Step 10</b>	<b>end</b> <b>Example:</b> Device (config)# <b>end</b>	Exits global configuration mode and returns to privileged EXEC mode.
<b>Step 11</b>	<b>show interface</b> [ <i>interface-id</i> ] <b>rep</b> [ <b>detail</b> ] <b>Example:</b> Device (config)# <b>show interface gigabitethernet1/1 rep detail</b>	(Optional) Displays the REP interface configuration.
<b>Step 12</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device (config)# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the router startup configuration file.

## Setting Manual Preemption for VLAN Load Balancing

If you do not enter the `rep preempt delay seconds` interface configuration command on the primary edge port to configure a preemption time delay, the default is to manually trigger VLAN load balancing on the segment. Be sure that all the other segment configurations have been completed before manually preempting VLAN load balancing. When you enter the `rep preempt delay segment segment-id` command, a confirmation message is displayed before the command is executed because preemption might cause network disruption.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>rep preempt segment segment-id</b> <b>Example:</b> Device# <code>rep preempt segment 100</code> The command will cause a momentary traffic disruption. Do you still want to continue? [confirm]	Manually triggers VLAN load balancing on the segment.  You need to confirm the command before it is executed.
<b>Step 4</b>	<b>show rep topology segment segment-id</b> <b>Example:</b> Device# <code>show rep topology segment 100</code>	(Optional) Displays REP topology information.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device# <code>end</code>	Exits privileged EXEC mode.

## Configuring SNMP Traps for REP

You can configure a router to send REP-specific traps to notify the Simple Network Management Protocol (SNMP) server of link-operational status changes and port role changes.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>snmp mib rep trap-rate <i>value</i></b> <b>Example:</b> Device(config)# <code>snmp mib rep trap-rate 500</code>	Enables the switch to send REP traps, and sets the number of traps sent per second. <ul style="list-style-type: none"> <li>• Enter the number of traps sent per second. The range is from 0 to 1000. The default is 0 (no limit is imposed; a trap is sent at every occurrence).</li> </ul>
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 4</b>	<b>show running-config</b> <b>Example:</b> Device# <code>show running-config</code>	(Optional) Displays the running configuration, which can be used to verify the REP trap configuration.
<b>Step 5</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the switch startup configuration file.

## Monitoring Resilient Ethernet Protocol Configurations

You can display the rep interface and rep topology details using the commands in this topic.

**Procedure****Step 1** `show interface [interface-id] rep [detail]`

Displays REP configuration and status for an interface or for all the interfaces.

- (Optional) **detail**—Displays interface-specific REP information.

**Example:**

```
Device# show interfaces TenGigabitEthernet4/1 rep detail
```

```
TenGigabitEthernet4/1 REP enabled
Segment-id: 3 (Primary Edge)
```



```

PortID: 03010015FA66FF80
Preferred flag: No
Operational Link Status: TWO_WAY
Current Key: 02040015FA66FF804050
Port Role: Open
Blocked VLAN: <empty>
Admin-vlan: 1
Preempt Delay Timer: disabled
Configured Load-balancing Block Port: none
Configured Load-balancing Block VLAN: none
STCN Propagate to: none
LSL PDU rx: 999, tx: 652
HFL PDU rx: 0, tx: 0
BPA TLV rx: 500, tx: 4
BPA (STCN, LSL) TLV rx: 0, tx: 0
BPA (STCN, HFL) TLV rx: 0, tx: 0
EPA-ELECTION TLV rx: 6, tx: 5
EPA-COMMAND TLV rx: 0, tx: 0
EPA-INFO TLV rx: 135, tx: 136

```

**Step 2** `show rep topology [segment segment-id] [archive ] [detail]`

Displays REP topology information for a segment or for all the segments, including the primary and secondary edge ports in the segment.

- (Optional) **archive**—Displays the last stable topology.

**Note** An archive topology is not retained when the switch reloads.

- (Optional) **detail**—Displays detailed archived information.

**Example:**

```
Device# show rep topology
```

```

REP Segment 1
BridgeName      PortName      Edge Role
-----
10.64.106.63   Te5/4         Pri  Open
10.64.106.228 Te3/4         Open
10.64.106.228 Te3/3         Open
10.64.106.67  Te4/3         Open
10.64.106.67  Te4/4         Alt
10.64.106.63  Te4/4         Sec  Open

```

```

REP Segment 3
BridgeName      PortName      Edge Role
-----
10.64.106.63   Gi50/1        Pri  Open
SVT_3400_2     Gi0/3         Open
SVT_3400_2     Gi0/4         Open
10.64.106.68   Gi40/2        Open
10.64.106.68   Gi40/1        Open
10.64.106.63   Gi50/2        Sec  Alt

```





## CHAPTER 49

# Configuring UniDirectional Link Detection

- [Restrictions for Configuring UDLD, on page 853](#)
- [Information About UDLD, on page 853](#)
- [How to Configure UDLD, on page 856](#)
- [Monitoring and Maintaining UDLD, on page 858](#)
- [Additional References for UDLD, on page 858](#)
- [Feature Information for UDLD, on page 859](#)

## Restrictions for Configuring UDLD

The following are restrictions for configuring UniDirectional Link Detection (UDLD):

- A UDLD-capable port cannot detect a unidirectional link if it is connected to a UDLD-incapable port of another device.
- When configuring the mode (normal or aggressive), make sure that the same mode is configured on both sides of the link.
- You can configure UDLD in interface configuration mode and the configuration is accepted by the device; however, this configuration is not displayed in the running configuration, nor is it saved.



### Caution

Loop guard works only on point-to-point links. We recommend that each end of the link has a directly connected device that is running STP.

## Information About UDLD

UniDirectional Link Detection (UDLD) is a Layer 2 protocol that enables devices connected through fiber-optic or twisted-pair Ethernet cables to monitor the physical configuration of the cables and detect when a unidirectional link exists. All connected devices must support UDLD for the protocol to successfully identify and disable unidirectional links. When UDLD detects a unidirectional link, it disables the affected port and alerts you. Unidirectional links can cause a variety of problems, including spanning-tree topology loops.

## Modes of Operation

UDLD has two modes of operation: normal (the default) and aggressive. In normal mode, UDLD can detect unidirectional links due to misconnected ports on fiber-optic connections. In aggressive mode, UDLD can also detect unidirectional links due to one-way traffic on fiber-optic and twisted-pair links and to misconnected ports on fiber-optic links.

In normal and aggressive modes, UDLD works with the Layer 1 mechanisms to learn the physical status of a link. At Layer 1, autonegotiation takes care of physical signaling and fault detection. UDLD performs tasks that autonegotiation cannot perform, such as detecting the identities of neighbors and shutting down misconnected ports. When you enable both autonegotiation and UDLD, the Layer 1 and Layer 2 detections work together to prevent physical and logical unidirectional connections and the malfunctioning of other protocols.

A unidirectional link occurs whenever traffic sent by a local device is received by its neighbor but traffic from the neighbor is not received by the local device.

### Normal Mode

In normal mode, UDLD detects a unidirectional link when fiber strands in a fiber-optic port are misconnected and the Layer 1 mechanisms do not detect this misconnection. If the ports are connected correctly but the traffic is one way, UDLD does not detect the unidirectional link because the Layer 1 mechanism, which is supposed to detect this condition, does not do so. In this case, the logical link is considered undetermined, and UDLD does not disable the port.

When UDLD is in normal mode, if one of the fiber strands in a pair is disconnected, as long as autonegotiation is active, the link does not stay up because the Layer 1 mechanisms detects a physical problem with the link. In this case, UDLD does not take any action and the logical link is considered undetermined.

### Aggressive Mode

In aggressive mode, UDLD detects a unidirectional link by using the previous detection methods. UDLD in aggressive mode can also detect a unidirectional link on a point-to-point link on which no failure between the two devices is allowed. It can also detect a unidirectional link when one of these problems exists:

- On fiber-optic or twisted-pair links, one of the ports cannot send or receive traffic.
- On fiber-optic or twisted-pair links, one of the ports is down while the other is up.
- One of the fiber strands in the cable is disconnected.

In these cases, UDLD disables the affected port.

In a point-to-point link, UDLD hello packets can be considered as a heart beat whose presence guarantees the health of the link. Conversely, the loss of the heart beat means that the link must be shut down if it is not possible to reestablish a bidirectional link.

If both fiber strands in a cable are working normally from a Layer 1 perspective, UDLD in aggressive mode detects whether those fiber strands are connected correctly and whether traffic is flowing bidirectionally between the correct neighbors. This check cannot be performed by autonegotiation because autonegotiation operates at Layer 1.



**Note** Uddl is enabled with uddl aggressive mode globally. When Rx cable or Tx is cable from switch1 , then the switch1 and switch2 ports will go into **Not connected** state. They do not go to **error disabled** state. Also the port does not show any light if you check the physical connection.

Switch1 (Tx)\_\_\_\_\_ (Rx) Switch2

Switch1 (Rx)\_\_\_\_\_ (Tx) Switch2

## Methods to Detect Unidirectional Links

UDLD operates by using two methods:

- Neighbor database maintenance
- Event-driven detection and echoing

### Neighbor Database Maintenance

UDLD learns about other UDLD-capable neighbors by periodically sending a hello packet (also called an advertisement or probe) on every active port to keep each device informed about its neighbors.

When the device receives a hello message, it caches the information until the age time (hold time or time-to-live) expires. If the device receives a new hello message before an older cache entry ages, the device replaces the older entry with the new one.

Whenever a port is disabled and UDLD is running, whenever UDLD is disabled on a port, or whenever the device is reset, UDLD clears all existing cache entries for the ports affected by the configuration change. UDLD sends at least one message to inform the neighbors to flush the part of their caches affected by the status change. The message is intended to keep the caches synchronized.

### Event-Driven Detection and Echoing

UDLD relies on echoing as its detection operation. Whenever a UDLD device learns about a new neighbor or receives a resynchronization request from an out-of-sync neighbor, it restarts the detection window on its side of the connection and sends echo messages in reply. Because this behavior is the same on all UDLD neighbors, the sender of the echoes expects to receive an echo in reply.

If the detection window ends and no valid reply message is received, the link might shut down, depending on the UDLD mode. When UDLD is in normal mode, the link might be considered undetermined and might not be shut down. When UDLD is in aggressive mode, the link is considered unidirectional, and the port is disabled.

### UDLD Reset Options

If an interface becomes disabled by UDLD, you can use one of the following options to reset UDLD:

- The **udld reset** interface configuration command.
- The **shutdown** interface configuration command followed by the **no shutdown** interface configuration command restarts the disabled port.
- The **no udld {aggressive | enable}** global configuration command followed by the **udld {aggressive | enable}** global configuration command reenables the disabled ports.

- The **no udld port** interface configuration command followed by the **udld port [aggressive]** interface configuration command reenables the disabled fiber-optic port.
- The **errdisable recovery cause udld** global configuration command enables the timer to automatically recover from the UDLD error-disabled state, and the **errdisable recovery interval interval** global configuration command specifies the time to recover from the UDLD error-disabled state.

## Default UDLD Configuration

Table 65: Default UDLD Configuration

Feature	Default Setting
UDLD global enable state	Globally disabled
UDLD per-port enable state for fiber-optic media	Disabled on all Ethernet fiber-optic ports
UDLD per-port enable state for twisted-pair (copper) media	Disabled on all Ethernet 10/100 and 1000BASE-TX ports
UDLD aggressive mode	Disabled

## How to Configure UDLD

### Enabling UDLD Globally (CLI)

Follow these steps to enable UDLD in the aggressive or normal mode and to set the configurable message timer on all fiber-optic ports on the device.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>udld {aggressive   enable   message time message-timer-interval}</b>  <b>Example:</b>  Device(config)# <b>udld enable message time 10</b>	Specifies the UDLD mode of operation: <ul style="list-style-type: none"> <li>• <b>aggressive</b>—Enables UDLD in aggressive mode on all fiber-optic ports.</li> <li>• <b>enable</b>—Enables UDLD in normal mode on all fiber-optic ports on the device. UDLD is disabled by default.</li> </ul>

	Command or Action	Purpose
		<p>An individual interface configuration overrides the setting of the <b>udld enable</b> global configuration command.</p> <ul style="list-style-type: none"> <li>• <b>message time</b> <i>message-timer-interval</i>—Configures the period of time between UDLD probe messages on ports that are in the advertisement phase and are detected to be bidirectional. The range is from 1 to 90 seconds; the default value is 15.</li> </ul> <p><b>Note</b> This command affects fiber-optic ports only. Use the <b>udld</b> interface configuration command to enable UDLD on other port types.</p> <p>Use the <b>no</b> form of this command, to disable UDLD.</p>
<b>Step 3</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.

## Enabling UDLD on an Interface (CLI)

Follow these steps either to enable UDLD in the aggressive or normal mode or to disable UDLD on a port.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<p><b>interface</b> <i>interface-id</i></p> <p><b>Example:</b></p> <pre>Device(config)# interface gigabitethernet</pre>	Specifies the port to be enabled for UDLD, and enters interface configuration mode.
<b>Step 3</b>	<b>udld port [aggressive]</b>	UDLD is disabled by default.

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config-if)# udld port aggressive</pre>	<ul style="list-style-type: none"> <li>• <b>udld port</b>—Enables UDLD in normal mode on the specified port.</li> <li>• <b>udld port aggressive</b>—(Optional) Enables UDLD in aggressive mode on the specified port.</li> </ul> <p><b>Note</b> Use the <b>no udld port</b> interface configuration command to disable UDLD on a specified fiber-optic port.</p>
<b>Step 4</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.

## Monitoring and Maintaining UDLD

Command	Purpose
<code>show udld [interface-id   neighbors]</code>	Displays the UDLD status for the specified port or for all ports.

## Additional References for UDLD

### Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	<i>Layer 2/3 Command Reference (Catalyst 3850 Switches)</i>

### Standards and RFCs

Standard/RFC	Title
None	—



**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for UDL

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.





## PART IX

# Lightweight Access Points

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- [Configuring Retransmission Interval and Retry Count, on page 875](#)
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## CHAPTER 50

# Configuring the Device for Access Point Discovery

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## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Configuring the Device for Access Point Discovery



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**Caution** You should connect APs directly to the Cisco Catalyst 3850 switch ports to use its wireless functionality.

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- Ensure that the Control and Provisioning of Wireless Access Points (CAPWAP) UDP ports 5246 and 5247 (similar to the Lightweight Access Point Protocol (LWAPP) UDP ports 12222 and 12223) are enabled and are not blocked by an intermediate device that could prevent an access point from joining the device.
- If access control lists (ACLs) are in the control path between the device and its access points, you must open new protocol ports to prevent access points from being stranded.

- If an access point is in the UP state and its IP address changes, the access point tears down the existing CAPWAP tunnel and rejoins the device.
- Access points must be discovered by a device before they can become an active part of the network. The lightweight access points support the following device discovery processes:
  - Layer 3 CAPWAP discovery—You can enable this feature on different subnets from the access point. This feature uses IP addresses and UDP packets rather than the MAC addresses used by Layer 2 discovery.
  - Locally stored device IP address discovery—If the access point was previously associated to a device, the IP addresses of the primary, secondary, and tertiary devices are stored in the access point's nonvolatile memory. This process of storing device IP addresses on an access point for later deployment is called *priming the access point*.
  - DHCP server discovery—This feature uses DHCP option 43 to provide device IP addresses to the access points. Cisco switches support a DHCP server option that is typically used for this capability.
  - DNS discovery—The access point can discover devices through your domain name server (DNS). You must configure your DNS to return device IP addresses in response to CISCO-CAPWAP-CONTROLLER.localdomain, where localdomain is the access point domain name. When an access point receives an IP address and DNS information from a DHCP server, it contacts the DNS to resolve CISCO-CAPWAP-CONTROLLER.localdomain. When the DNS sends a list of device IP addresses, the access point sends discovery requests to the devices.

## Restrictions for Configuring the Device for Access Point Discovery

- Ensure that the devices are configured with the correct date and time. If the date and time configured on the device precedes the creation and installation date of certificates on the access points, the access point fails to join the device.
- During the discovery process, access points that are supported by the Cisco device, such as the 1140, 1260, 3500, 1040, 1600, 2600, or 3600 query only for Cisco devices.
- Do not configure same VLAN for both wireless management and wireless clients.

## Information About Configuring the Device for Access Point Discovery

In a CAPWAP environment, a lightweight access point discovers a device by using CAPWAP discovery mechanisms and then sends a CAPWAP join request to the device. The device sends a CAPWAP join response to the access point that allows the access point to join the device. When the access point joins the device, the device manages its configuration, firmware, control transactions, and data transactions.

## Access Point Communication Protocols

Cisco lightweight access points use the IETF standard CAPWAP to communicate with the device and other lightweight access points on the network.

CAPWAP, which is based on LWAPP, is a standard, interoperable protocol that enables a device to manage a collection of wireless access points. CAPWAP is implemented in device for these reasons:

- To provide an upgrade path from Cisco products that use LWAPP to next-generation Cisco products that use CAPWAP
- To manage RFID readers and similar devices
- To enable devices to interoperate with third-party access points in the future

## Viewing Access Point Join Information

Join statistics for an access point that sends a CAPWAP discovery request to the device at least once are maintained on the device even if the access point is rebooted or disconnected. These statistics are removed only when the device is rebooted or when you choose to clear the statistics.

## Troubleshooting the Access Point Join Process

Access points can fail to join a device for many reasons such as a RADIUS authorization is pending, self-signed certificates are not enabled on the device, the access point and device's regulatory domains do not match, and so on.

You can configure the access points to send all CAPWAP-related errors to a syslog server. You do not need to enable any debug commands on the device because all of the CAPWAP error messages can be viewed from the syslog server itself.

The state of the access point is not maintained on the device until it receives a CAPWAP join request from the access point, so it can be difficult to determine why the CAPWAP discovery request from a certain access point was rejected. In order to troubleshoot such joining issues without enabling CAPWAP debug commands on the device, the device collects information for all access points that send a discovery message to this device and maintains information for any access points that have successfully joined this device.

The device collects all join-related information for each access point that sends a CAPWAP discovery request to the device. Collection begins when the first discovery message is received from the access point and ends when the last configuration payload is sent from the device to the access point.

When the device is maintaining join-related information for the maximum number of access points, it does not collect information for any more access points.

You can also configure a DHCP server to return a syslog server IP address to the access point using option 7 on the server. The access point then starts sending all syslog messages to this IP address.

You can configure the syslog server IP address through the access point CLI, if the access point is not connected to the device by entering the **capwap ap log-server *syslog\_server\_IP\_address*** command.

When the access point joins a device for the first time, the device pushes the global syslog server IP address (the default is 255.255.255.255) to the access point. After that, the access point sends all syslog messages to this IP address, until it is overridden by one of the following scenarios:

- The access point is still connected to the same device, and you changed the global syslog server IP address configuration on the device by using the **ap syslog host** *Syslog\_Server\_IP\_Address* command. In this case, the device pushes the new global syslog server IP address to the access point.
- The access point is still connected to the same device, and you configured a specific syslog server IP address for the access point on the device by using the **ap name** *Cisco\_AP* **syslog host** *Syslog\_Host\_IP\_Address* command. In this case, the device pushes the new specific syslog server IP address to the access point.
- The access point gets disconnected from the device, and you configured the syslog server IP address from the access point CLI by using the **capwap ap log-server** *syslog\_server\_IP\_address* command. This command works only if the access point is not connected to any device.
- The access point gets disconnected from the device and joins another device. In this case, the new device pushes its global syslog server IP address to the access point.

Whenever a new syslog server IP address overrides the existing syslog server IP address, the old address is erased from persistent storage, and the new address is stored in its place. The access point also starts sending all syslog messages to the new IP address, if the access point can reach the syslog server IP address.

## How to Configure Access Point Discovery

### Configuring the Syslog Server for Access Points (CLI)

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>show ap config global</b>  <b>Example:</b> Device# show ap config global	Displays the global syslog server settings for all access points that join the device.
<b>Step 2</b>	<b>show ap name</b> <i>Cisco_AP</i> <b>config general</b>  <b>Example:</b> Device# show ap name AP03 config general	Displays the syslog server settings for a specific access point.

### Monitoring Access Point Join Information (CLI)



**Note** The procedure to perform this task using the device GUI is not currently available.



**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device# enable	Enters privileged EXEC mode.
<b>Step 2</b>	<b>show ap join stats summary</b> <b>Example:</b> Device# show ap join stats summary	Displays the MAC addresses of all the access points that are joined to the device or that have tried to join.
<b>Step 3</b>	<b>show ap mac-address <i>mac_address</i> join stats summary</b> <b>Example:</b> Device# show ap mac-address 000.2000.0400 join stats summary	Displays all the statistics for the AP including the last join error detail.
<b>Step 4</b>	<b>show ap mac-address <i>mac_address</i> join stats detailed</b> <b>Example:</b> Device# show ap mac-address 000.2000.0400 join stats detailed	Displays all join-related statistics collected for a specific access point.
<b>Step 5</b>	<b>clear ap join statistics</b> <b>Example:</b> Device# clear ap join statistics	Clears the join statistics for all access points.  <b>Note</b> To clear the join statistics that correspond to specific access points, enter the <b>clear ap mac-address <i>mac_address</i> join statistics</b> command.

**Related Topics**

[Displaying the MAC Addresses of all Access Points: Example](#), on page 867

[DHCP Option 43 for Lightweight Cisco Aironet Access Points Configuration Example](#), on page 869

# Configuration Examples for Configuring the Device for Access Point Discovery

## Displaying the MAC Addresses of all Access Points: Example

This example shows how to display MAC addresses of all the access points that are joined to the device:

```
Device# show ap join stats summary
Number of APs..... 4

Base Mac           EthernetMac       AP Name IP Address   Status
-----
```

```

00:0b:85:57:bc:c0 00:0b:85:57:bc:c0 AP1130 10.10.163.217 Joined
00:1c:0f:81:db:80 00:1c:63:23:ac:a0 AP1140 10.10.163.216 Not joined
00:1c:0f:81:fc:20 00:1b:d5:9f:7d:b2 AP1 10.10.163.215 Joined
00:21:1b:ea:36:60 00:0c:d4:8a:6b:c1 AP2 10.10.163.214 Not joined

```

This example shows how to display the last join error details for a specific access point:

```

Device# show ap mac-address 000.2000.0400 join stats summary
Is the AP currently connected to controller..... Yes
Time at which the AP joined this
controller last time..... Aug 21 12:50:36.061
Type of error
that occurred last..... AP got or has been disconnected
Reason for error
that occurred last..... The AP has been reset by the controller
Time at which the last join error occurred..... Aug 21 12:50:34.374

```

This example shows how to display all join-related statistics collected for a specific access point:

```

Device# show ap mac-address 000.2000.0400 join stats detailed
Discovery phase statistics
- Discovery requests received..... 2
- Successful discovery responses sent..... 2
- Unsuccessful discovery request processing..... 0
- Reason for last unsuccessful discovery attempt.... Not applicable
- Time at last successful discovery attempt..... Aug 21 12:50:23.335
- Time at last unsuccessful discovery attempt..... Not applicable

Join phase statistics
- Join requests received..... 1
- Successful join responses sent..... 1
- Unsuccessful join request processing..... 1
- Reason for last unsuccessful join attempt..... RADIUS authorization
is pending
for the AP
- Time at last successful join attempt..... Aug 21 12:50:34.481
- Time at last unsuccessful join attempt..... Aug 21 12:50:34.374

Configuration phase statistics
- Configuration requests received..... 1
- Successful configuration responses sent..... 1
- Unsuccessful configuration request processing..... 0
- Reason for last unsuccessful configuration attempt.. Not applicable
- Time at last successful configuration attempt..... Aug 21 12:50:34.374
- Time at last unsuccessful configuration attempt..... Not applicable

Last AP message decryption failure details
- Reason for last message decryption failure..... Not applicable

Last AP disconnect details
- Reason for last AP connection failure..... The AP has been reset by
the controller

Last join error summary
- Type of error that occurred last..... AP got or has been
disconnected
- Reason for error that occurred last..... The AP has been reset
by the controller
- Time at which the last join error occurred..... Aug 21 12:50:34.374

```

# DHCP Option 43 for Lightweight Cisco Aironet Access Points Configuration Example

For more information about the AP join process, see *DHCP OPTION 43 for Lightweight Cisco Aironet Access Points Configuration Example*.

## Configuring AP Pass Through

### Information About AP Pass Through

AP pass through allows all the access points connected to Cisco Catalyst 3850 Series Switches and Cisco Catalyst 3650 Series Switches to join another controller on the network.

Prior to this release, all access points connected Cisco Catalyst 3850 Series Switches and Cisco Catalyst 3650 Series Switches would be terminated on the device when the wireless management vlan is turned on. Unsupported access points connected to the device were unable join a controller on a different vlan. AP pass through allows the connected AP to join another wireless controller on the network by assigning different vlan.

The advantages of AP pass through are:

- Allows partial deployment of Cisco New Generation Wireless Controllers where some APs are connected to Cisco Catalyst 3850 Series Switches and Cisco Catalyst 3650 Series Switches but other APs continue to join other controllers on the network.
- The APs that are not supported on the Cisco Catalyst 3850 Series Switches and Cisco Catalyst 3650 Series Switches are allowed to join other controllers on the network.
- The wireless LAN controller is used to provide access to both wired and wireless guests. AP Pass through allows the AP to pass through Cisco Catalyst 3850 Series Switches and Cisco Catalyst 3650 Series Switches to join any other controller when wired guest accessing is turned on.

### Configuring AP Pass Through

All access points on VLANs other than the one with supported access points will be put into the AP pass-through mode and will not terminate on the device.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>wireless management interface vlan</b> <i>vlan_id</i>  <b>Example:</b>	Configures the ports that are connected to the supported access points with the wireless management VLAN

	Command or Action	Purpose
	Device(config)# wireless management interface vlan10	
<b>Step 3</b>	<b>interface GigabitEthernet1/0/1</b>  <b>Example:</b> Device(config)# interface TenGigabitEthernet1/0/1	Sets the 10-Gigbit Ethernet interface.  The command prompt changes from (config)# to (config-if)#.
<b>Step 4</b>	<b>description Supported AP switchport access <i>vlan_id</i></b>  <b>Example:</b> Device(config-if)# switchport access vlan10	Specifies the VLAN for which this access port will carry traffic
<b>Step 5</b>	<b>description Unsupported AP switchport access <i>vlan_id</i></b>  <b>Example:</b> Device(config-if)# switchport access vlan20	Configures the ports that are connected to the unsupported access points with a vlan other than the wireless management VLAN.



## CHAPTER 51

# Configuring Data Encryption

- [Finding Feature Information, on page 871](#)
- [Prerequisites for Configuring Data Encryption, on page 871](#)
- [Restrictions for Configuring Data Encryption, on page 871](#)
- [Information About Data Encryption, on page 872](#)
- [How to Configure Data Encryption, on page 872](#)
- [Configuration Examples for Configuring Data Encryption, on page 873](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Configuring Data Encryption

- Cisco 1260, 3500, 3600, 801, 1140, 1310, and 1520 series access points support Datagram Transport Layer Security (DTLS) data encryption.
- You can use the device to enable or disable DTLS data encryption for a specific access point or for all access points.
- Non-Russian customers who use the Cisco device do not need a data DTLS license.

## Restrictions for Configuring Data Encryption

- Encryption limits throughput at both the device and the access point, and maximum throughput is desired for most enterprise networks.
- If your device does not have a data DTLS license and if the access point associated with the device has DTLS enabled, the data path will be unencrypted.

- In images that do not have a DTLS license, the DTLS commands are not available.

## Information About Data Encryption

The device enables you to encrypt Control and Provisioning of Wireless Access Points (CAPWAP) control packets (and optionally, CAPWAP data packets) that are sent between the access point and the device using DTLS. DTLS is a standards-track Internet Engineering Task Force (IETF) protocol based on TLS. CAPWAP control packets are management packets exchanged between a device and an access point while CAPWAP data packets encapsulate forwarded wireless frames. CAPWAP control and data packets are sent over separate UDP ports: 5246 (control) and 5247 (data). If an access point does not support DTLS data encryption, DTLS is enabled only for the control plane, and a DTLS session for the data plane is not established.

## How to Configure Data Encryption

### Configuring Data Encryption (CLI)

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ap link-encryption</b> <b>Example:</b> Device(config)# <code>ap link-encryption</code>	Enables data encryption for all access points or a specific access point by entering this command. The default value is disabled.  Changing the data encryption mode requires the access points to rejoin the device.
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 4</b>	<b>show ap link-encryption</b> <b>Example:</b> Device# <code>show ap link-encryption</code>	Displays the encryption state of all access points or a specific access point. This command also shows authentication errors, which track the number of integrity check failures and replay errors. Relay errors help in tracking the number of times the access point receives the same packet.
<b>Step 5</b>	<b>show wireless dtls connections</b> <b>Example:</b>	Displays a summary of all active DTLS connections.

	Command or Action	Purpose
	Device# show wireless dtls connections	<b>Note</b> If you experience any problems with DTLS data encryption, enter the <b>debug dtls ap {all   event   trace}</b> command to debug all DTLS messages, events, or traces.

**Related Topics**

[Displaying Data Encryption States for all Access Points: Examples](#), on page 873

## Configuration Examples for Configuring Data Encryption

### Displaying Data Encryption States for all Access Points: Examples

This example shows how to display the encryption state of all access points or a specific access point. This command also shows authentication errors, which track the number of integrity check failures and replay errors. Relay errors help in tracking the number of times the access point receives the same packet:

```
Device# show ap link-encryption
      Encryption  Dnstream  Upstream  Last
AP Name          State      Count     Count     Update
-----
3602a             Enabled    0         0         Never
```

This example shows how to display a summary of all active DTLS connections:

```
Device# show wireless dtls connections
AP Name          Local Port  Peer IP    Peer Port  Ciphersuite
-----
3602a            Capwap_Ctrl 10.10.21.213 46075     TLS_RSA_WITH_AES_128_CBC_SHA
3602a            Capwap_Data 10.10.21.213 46075     TLS_RSA_WITH_AES_128_CBC_SHA
```







## CHAPTER 52

# Configuring Retransmission Interval and Retry Count

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- [Finding Feature Information, on page 875](#)
- [Prerequisites for Configuring the Access Point Retransmission Interval and Retry Count, on page 875](#)
- [Information About Retransmission Interval and Retry Count, on page 876](#)
- [How to Configure Access Point Retransmission Interval and Retry Count, on page 876](#)
- [Viewing CAPWAP Maximum Transmission Unit Information \(CLI\), on page 877](#)
- [Configuration Examples for Configuring Access Point Retransmission Interval and Retry Count, on page 878](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

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## Prerequisites for Configuring the Access Point Retransmission Interval and Retry Count

- You can configure the retransmission intervals and retry count both at a global and a specific access point level. A global configuration applies these configuration parameters to all the access points. Alternatively, when you configure the retransmission level and retry count at a specific access point level, the values are applied to that particular access point. The access point specific configuration has a higher precedence than the global configuration.

## Information About Retransmission Interval and Retry Count

The device and the access points exchange packets using the Control and Provisioning of Wireless Access Points (CAPWAP) reliable transport protocol. For each request, a response is defined. This response is used to acknowledge the receipt of the request message. Response messages are not explicitly acknowledged; therefore, if a response message is not received, the original request message is retransmitted after the retransmit interval. If the request is not acknowledged after a maximum number of retransmissions, the session is closed and the access points reassociate with another device.

## How to Configure Access Point Retransmission Interval and Retry Count

### Configuring the Access Point Retransmission Interval and Retry Count (CLI)

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b> Device# <b>enable</b>	Enters privileged EXEC mode.
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ap capwap retransmit interval</b> <i>interval_time</i>  <b>Example:</b> Device(config)# ap capwap retransmit interval 2	Configures the control packet retransmit interval for all access points globally.  <b>Note</b> The range for the interval parameter is from 2 to 5.
<b>Step 4</b>	<b>ap capwap retransmit count</b> <i>count_value</i>  <b>Example:</b> Device(config)# ap capwap retransmit count 3	Configures the control packet retry count for all access points globally.  <b>Note</b> The range for the count is from 3 to 8.
<b>Step 5</b>	<b>end</b>  <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 6</b>	<b>ap name</b> <i>Cisco_AP</i> <b>capwap retransmit interval</b> <i>interval_time</i>	Configures the control packet retransmit interval for the individual access point that you specify.

	Command or Action	Purpose
	<b>Example:</b> <pre>Device# ap name AP02 capwap retransmit interval 2</pre>	<b>Note</b> The range for the interval is from 2 to 5.  <b>Note</b> You must be in privileged EXEC mode to use the <b>ap name</b> commands.
<b>Step 7</b>	<b>ap name <i>Cisco_AP</i> capwap retransmit count <i>count_value</i></b>  <b>Example:</b> <pre>Device# ap name AP02 capwap retransmit count 3</pre>	Configures the control packet retry count for the individual access point that you specify.  <b>Note</b> The range for the retry count is from 3 to 8.
<b>Step 8</b>	<b>show ap capwap retransmit</b>  <b>Example:</b> <pre>Device# show ap capwap retransmit</pre>	Displays the CAPWAP retransmit details.

## Viewing CAPWAP Maximum Transmission Unit Information (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b> <pre>Device# enable</pre>	Enters privileged EXEC mode.
<b>Step 2</b>	<b>show ap name <i>Cisco_AP</i> config general</b>  <b>Example:</b> <pre>Device# show ap name Maria-1250 config general   include MTU</pre>	Displays the maximum transmission unit (MTU) for the CAPWAP path on the device. The MTU specifies the maximum size of any packet (in bytes) in a transmission.

### Related Topics

[Viewing the CAPWAP Retransmission Details: Example](#), on page 878

[Viewing Maximum Transmission Unit Information: Example](#), on page 878

# Configuration Examples for Configuring Access Point Retransmission Interval and Retry Count

## Viewing the CAPWAP Retransmission Details: Example

Enter the following command:

```
Device# show ap capwap retransmit
Global control packet retransmit interval : 3
Global control packet retransmit count : 5
```

AP Name	Retransmit Interval	Retransmit Count
-----	-----	-----
3602a	5	3

## Viewing Maximum Transmission Unit Information: Example

This example shows how to view the maximum transmission unit (MTU) for the CAPWAP path on the device. The MTU specifies the maximum size of any packet (in bytes) in a transmission:

```
Device# show ap name cisco-ap-name config general | include MTU
CAPWAP Path MTU..... 1500
```



## CHAPTER 53

# Configuring Adaptive Wireless Intrusion Prevention System

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- [Finding Feature Information, on page 879](#)
- [Prerequisites for Configuring wIPS, on page 879](#)
- [How to Configure wIPS on Access Points, on page 880](#)
- [Monitoring wIPS Information, on page 881](#)
- [Configuration Examples for Configuring wIPS on Access Points, on page 882](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

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## Prerequisites for Configuring wIPS

- The regular local mode access point has been extended with a subset of Wireless Intrusion Prevention System (wIPS) capabilities. This feature enables you to deploy your access points to provide protection without needing a separate overlay network.

# How to Configure wIPS on Access Points

## Configuring wIPS on an Access Point (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>ap name <i>Cisco_AP</i> mode local</b> <b>Example:</b> <pre>Device# ap name AP01 mode local</pre>	Configures an access point for monitor mode.  A message appears that indicates that changing the AP's mode causes the access point to reboot. This message also displays a prompt that enables you to specify whether or not you want to continue with changing the AP mode. Enter <b>y</b> at the prompt to continue.
<b>Step 2</b>	<b>ap name <i>Cisco_AP</i> dot11 5ghz shutdown</b> <b>Example:</b> <pre>Device# ap name AP01 dot11 5ghz shutdown</pre>	Disables the 802.11a radio on the access point.
<b>Step 3</b>	<b>ap name <i>Cisco_AP</i> dot11 24ghz shutdown</b> <b>Example:</b> <pre>Device# ap name AP02 dot11 24ghz shutdown</pre>	Disables the 802.11b radio on the access point.
<b>Step 4</b>	<b>ap name <i>Cisco_AP</i> mode monitor submode wips</b> <b>Example:</b> <pre>Device# ap name AP01 mode monitor submode wips</pre>	Configures the wIPS submode on the access point.  <b>Note</b> To disable wIPS on the access point, enter the <b>ap name <i>Cisco_AP</i> modemonitor submode none</b> command.
<b>Step 5</b>	<b>ap name <i>Cisco_AP</i> monitor-mode wips-optimized</b> <b>Example:</b> <pre>Device# ap name AP01 monitor-mode wips-optimized</pre>	Enables wIPS optimized channel scanning for the access point.  The access point scans each channel for 250 milliseconds. It derives the list of channels to be scanned from the monitor configuration. You can choose the following options: <ul style="list-style-type: none"> <li>• <b>All</b>—All channels supported by the access point's radio.</li> <li>• <b>Country</b>—Only the channels supported by the access point's country of operation.</li> <li>• <b>DCA</b>—Only the channel set used by the dynamic channel assignment (DCA)</li> </ul>

	Command or Action	Purpose
		algorithm, which by default includes all of the nonoverlapping channels allowed in the access point's country of operation.
<b>Step 6</b>	<b>show ap dot11 24ghz monitor</b> <b>Example:</b> Device# show ap dot11 24ghz monitor	Displays the monitor configuration channel set. <b>Note</b> The 802.11b Monitor Channels value in the output of the command indicates the monitor configuration channel set.
<b>Step 7</b>	<b>ap name Cisco_AP no dot11 5ghz shutdown</b> <b>Example:</b> Device# ap name AP01 no dot11 5ghz shutdown	Enables the 802.11a radio on the access point.
<b>Step 8</b>	<b>ap name Cisco_AP no dot11 24ghz shutdown</b> <b>Example:</b> Device# ap name AP01 no dot11 24ghz shutdown	Enables the 802.11b radio on the access point.

## Monitoring WIPS Information



**Note** The procedure to perform this task using the device GUI is not currently available.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>show ap name Cisco_AP config general</b> <b>Example:</b> Device# show ap name AP01 config general	Displays information on the wIPS submode on the access point.
<b>Step 2</b>	<b>show ap monitor-mode summary</b> <b>Example:</b> Device# show ap monitor-mode summary	Displays the wIPS optimized channel scanning configuration on the access point.
<b>Step 3</b>	<b>show wireless wps wips summary</b> <b>Example:</b> Device# show wireless wps wips summary	Displays the wIPS configuration forwarded by NCS or Prime to the device.

	Command or Action	Purpose
<b>Step 4</b>	<b>show wireless wps wips statistics</b> <b>Example:</b> Device# show wireless wps wips statistics	Displays the current state of wIPS operation on the device.
<b>Step 5</b>	<b>clear wireless wips statistics</b> <b>Example:</b> Device# clear wireless wips statistics	Clears the wIPS statistics on the device.

**Related Topics**

[Displaying the Monitor Configuration Channel Set: Example](#), on page 882

[Displaying wIPS Information: Examples](#), on page 882

# Configuration Examples for Configuring wIPS on Access Points

## Displaying the Monitor Configuration Channel Set: Example

This example shows how to display the monitor configuration channel set:

```
Device# show ap dot11 24ghz monitor
Default 802.11b AP monitoring
802.11b Monitor Mode..... enable
802.11b Monitor Channels..... Country channels
802.11b AP Coverage Interval..... 180 seconds
802.11b AP Load Interval..... 60 seconds
802.11b AP Noise Interval..... 180 seconds
802.11b AP Signal Strength Interval..... 60 seconds
```

## Displaying wIPS Information: Examples

This example shows how to display information on the wIPS submode on the access point:

```
Device# show ap name AP01 config general
Cisco AP Identifier..... 3
Cisco AP Name..... AP1131:46f2.98ac
...
AP Mode ..... Monitor
Public Safety ..... Disabled Disabled
AP SubMode ..... WIPS
```

This example shows how to display the wIPS optimized channel scanning configuration on the access point:

```
Device# show ap monitor-mode summary
AP Name      Ethernet MAC  Status  Scanning
              Channel
              List
-----
AP1131:4f2.9a 00:16:4:f2:9:a WIPS    1,6,NA,NA
```

This example shows how to display the wIPS configuration forwarded by WCS to the device:



```
Device# show wireless wps wips summary
Policy Name..... Default
Policy Version..... 3
```

This example shows how to display the current state of wIPS operation on the device:

```
Device# show wireless wps wips statistics
Policy Assignment Requests..... 1
Policy Assignment Responses..... 1
Policy Update Requests..... 0
Policy Update Responses..... 0
Policy Delete Requests..... 0
Policy Delete Responses..... 0
Alarm Updates..... 13572
Device Updates..... 8376
Device Update Requests..... 0
Device Update Responses..... 0
Forensic Updates..... 1001
Invalid WIPS Payloads..... 0
Invalid Messages Received..... 0
CAPWAP Enqueue Failed..... 0
NMSP Enqueue Failed..... 0
NMSP Transmitted Packets..... 22950
NMSP Transmit Packets Dropped..... 0
NMSP Largest Packet..... 1377
```





## CHAPTER 54

# Configuring Authentication for Access Points

- [Finding Feature Information, on page 885](#)
- [Prerequisites for Configuring Authentication for Access Points, on page 885](#)
- [Restrictions for Configuring Authentication for Access Points, on page 886](#)
- [Information about Configuring Authentication for Access Points, on page 886](#)
- [How to Configure Authentication for Access Points, on page 886](#)
- [Configuration Examples for Configuring Authentication for Access Points, on page 892](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Configuring Authentication for Access Points

- You can set a global username, password, and enable password for all access points that are currently joined to the device and any that join in the future inherit as they join the device. If desired, you can override the global credentials and assign a unique username, password, and enable password for a specific access point.
- After an access point joins the device, the access point enables console port security, and you are prompted for your username and password whenever you log into the access point's console port. When you log in, you are in nonprivileged mode, and you must enter the enable password in order to use the privileged mode.
- The global credentials that you configure on the device are retained across device and access point reboots. They are overwritten only if the access point joins a new device that is configured with a global username and password. If the new device is not configured with global credentials, the access point retains the global username and password configured for the first device.
- You must track the credentials used by the access points. Otherwise, you might not be able to log into an access point's console port. If you need to return the access points to the default *Cisco/Cisco* username

and password, you must clear the device's configuration and the access point's configuration to return them to factory-default settings. To reset the default access point configuration, enter the **ap name Cisco AP mgmtuser username Cisco password Cisco** command. Entering the command does not clear the static IP address of the access point. Once the access point rejoins a device, it adopts the default *Cisco/Cisco* username and password.

- You can configure global authentication settings for all access points that are currently joined to the device and any that join in the future. If desired, you can override the global authentication settings and assign unique authentication settings for a specific access point.
- This feature is supported on the following hardware:
  - All Cisco switches that support authentication.
  - Cisco Aironet 1140, 1260, 1310, 1520, 1600, 2600, 3500, and 3600 access points

## Restrictions for Configuring Authentication for Access Points

- The device name in the AP configuration is case sensitive. Therefore, make sure to configure the exact system name on the AP configuration. Failure to do this results in the AP fallback not working.

## Information about Configuring Authentication for Access Points

Cisco IOS access points are shipped from the factory with *Cisco* as the default enable password. This password allows users to log into the nonprivileged mode and enter the **show** and **debug** commands that pose a security threat to your network. You must change the default enable password to prevent unauthorized access and to enable users to enter configuration commands from the access point's console port.

You can configure 802.1X authentication between a lightweight access point and a Cisco switch. The access point acts as an 802.1X supplicant and is authenticated by the switch where it uses EAP-FAST with anonymous PAC provisioning.

## How to Configure Authentication for Access Points

### Configuring Global Credentials for Access Points (CLI)

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b> Device# enable	Enters privileged EXEC mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ap mgmtuser username user_name password 0 password secret 0 secret_value</b> <b>Example:</b> Device(config)# ap mgmtuser apusr1 password appass 0 secret 0 appass1	Configures the global username and password and enables the password for all access points that are currently joined to the device and any access points that join the device in the future. In the command, the parameter 0 specifies that an unencrypted password will follow and 8 specifies that an AES encrypted password will follow.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 5</b>	<b>ap name Cisco_AP mgmtuser username user_name password password secret secret</b> <b>Example:</b> Device(config)# ap name TSIM_AP-2 mgmtuser apusr1 password appass secret secret	<p>Overrides the global credentials for a specific access point and assigns a unique username and password and enables password to this access point.</p> <p>The credentials that you enter in this command are retained across device and access point reboots and if the access point joins a new device.</p> <p><b>Note</b> If you want to force this access point to use the device's global credentials, enter the <b>ap name Cisco_AP no mgmtuser</b> command. The following message appears after you execute this command: "AP reverted to global username configuration."</p>
<b>Step 6</b>	<b>show ap summary</b> <b>Example:</b> Device# show ap summary	Displays a summary of all connected Cisco APs.
<b>Step 7</b>	<b>show ap name Cisco_AP config general</b> <b>Example:</b> Device# show ap name AP02 config general	<p>Displays the global credentials configuration for a specific access point.</p> <p><b>Note</b> If this access point is configured for global credentials, the AP User Mode text boxes shows "Automatic." If the global credentials have been overwritten for this access point, the AP User Mode text box shows "Customized."</p>

## Configuring Authentication for Access Points (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device# <b>enable</b>	Enters privileged EXEC mode.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ap dot1x username <i>user_name_value</i> password 0 <i>password_value</i></b> <b>Example:</b> Device(config)# ap dot1x username AP3 password 0 password	Configures the global authentication username and password for all access points that are currently joined to the device and any access points that join the device in the future. This command contains the following keywords and arguments: <ul style="list-style-type: none"> <li>• <b>username</b>—Specifies an 802.1X username for all access points.</li> <li>• <i>user-id</i>—Username.</li> <li>• <b>password</b>—Specifies an 802.1X password for all access points.</li> <li>• <b>0</b>—Specifies an unencrypted password.</li> <li>• <b>8</b>—Specifies an AES encrypted password.</li> <li>• <i>passwd</i>—Password.</li> </ul> <p><b>Note</b> You must enter a strong password for the password parameter. Strong passwords are at least eight characters long, contain a combination of uppercase and lowercase letters, numbers, and symbols, and are not a word in any language.</p>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 5</b>	<b>ap name <i>Cisco_AP</i> dot1x-user username <i>username_value</i> password <i>password_value</i></b> <b>Example:</b>	Overrides the global authentication settings and assigns a unique username and password to a specific access point. This command

	Command or Action	Purpose
	<pre>Device# ap name AP03 dot1x-user username apuser1 password appass</pre>	<p>contains the following keywords and arguments:</p> <ul style="list-style-type: none"> <li>• <b>username</b>—Specifies to add a username.</li> <li>• <i>user-id</i>—Username.</li> <li>• <b>password</b>—Specifies to add a password.</li> <li>• <b>0</b>—Specifies an unencrypted password.</li> <li>• <b>8</b>—Specifies an AES encrypted password.</li> <li>• <i>passwd</i>—Password.</li> </ul> <p><b>Note</b> You must enter a strong password for the password parameter. See the note in Step 2 for the characteristics of strong passwords.</p> <p>The authentication settings that you enter in this command are retained across device and access point reboots and whenever the access point joins a new device.</p>
<b>Step 6</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 7</b>	<p><b>no ap dot1x username <i>user_name_value</i></b> <b>password 0 <i>password_value</i></b></p> <p><b>Example:</b></p> <pre>Device(config)# no ap dot1x username dot1xusr password 0 dot1xpass</pre>	<p>Disables 802.1X authentication for all access points or for a specific access point.</p> <p>The following message appears after you execute this command: “AP reverted to global username configuration.”</p> <p><b>Note</b> You can disable 802.1X authentication for a specific access point only if global 802.1X authentication is not enabled. If global 802.1X authentication is enabled, you can disable 802.1X for all access points only.</p>
<b>Step 8</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 9</b>	<p><b>show ap summary</b></p> <p><b>Example:</b></p>	Displays the authentication settings for all access points that join the device.

	Command or Action	Purpose
	Device# show ap summary	<b>Note</b> If global authentication settings are not configured, the Global AP Dot1x User Name text box shows “Not Configured.”
<b>Step 10</b>	<b>show ap name Cisco_AP config general</b> <b>Example:</b> Device# show ap name AP02 config general	Displays the authentication settings for a specific access point. <b>Note</b> If this access point is configured for global authentication, the AP Dot1x User Mode text boxes shows “Automatic.” If the global authentication settings have been overwritten for this access point, the AP Dot1x User Mode text box shows “Customized.”

**Related Topics**

[Displaying the Authentication Settings for Access Points: Examples](#), on page 892

## Configuring the Switch for Authentication (CLI)



**Note** The procedure to perform this task using the device GUI is not currently available.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device# enable	Enters privileged EXEC mode.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>dot1x system-auth-control</b> <b>Example:</b> Device(config)# dot1x system-auth-control	Enables system authentication control.
<b>Step 4</b>	<b>aaa new-model</b> <b>Example:</b> Device(config)# aaa new-model	Enables new access control commands and functions.



	Command or Action	Purpose
<b>Step 5</b>	<b>aaa authentication dot1x default group radius</b> <b>Example:</b> <pre>Device(config)# aaa authentication dot1x default group radius</pre>	Sets the default authentications lists for IEEE 802.1X by using all the radius hosts in a server group.
<b>Step 6</b>	<b>radius server <i>server name</i></b> <b>Example:</b> <pre>Device(config)# radius server rsim</pre>	
<b>Step 7</b>	<b>address {ipv4   ipv6} <i>ip_address</i> {auth-port <i>port_number</i>   acct-port <i>port_number</i>}</b> <b>Example:</b> <pre>Device(config-radius-server)# address ipv4 124.2.2.12 auth-port 1612</pre>	(Optional) Specifies the RADIUS server parameters.  For <b>auth-port <i>port_number</i></b> , specify the UDP destination port for authentication requests. The default is 1645. The range is 0 to 65536.  For <b>acct-port <i>port_number</i></b> , specify the UDP destination port for authentication requests. The default is 1646.
<b>Step 8</b>	<b>key <i>unencrypted_server_key</i></b> <b>Example:</b> <pre>Device(config-radius-server)# key encryptkey</pre>	Sets a clear text encryption key for the RADIUS authentication server.
<b>Step 9</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-radius-server)# exit</pre>	Exits the RADIUS server mode and enters the global configuration mode.
<b>Step 10</b>	<b>interface TenGigabitEthernet1/0/1</b> <b>Example:</b> <pre>Device(config)# interface TenGigabitEthernet1/0/1</pre>	Sets the 10-Gigabit Ethernet interface.  The command prompt changes from Controller(config)# to Controller(config-if)#.
<b>Step 11</b>	<b>switch mode access</b> <b>Example:</b> <pre>Device(config-if)# switch mode access</pre>	Sets the unconditional trunking mode access to the interface.
<b>Step 12</b>	<b>dot1x pae authenticator</b> <b>Example:</b> <pre>Device(config-if)# dot1x pae authenticator</pre>	Sets the 802.1X interface PAE type as the authenticator.
<b>Step 13</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

**Related Topics**

[Displaying the Authentication Settings for Access Points: Examples](#), on page 892

# Configuration Examples for Configuring Authentication for Access Points

## Displaying the Authentication Settings for Access Points: Examples

This example shows how to display the authentication settings for all access points that join the device:

```
Device# show ap summary
Number of APs..... 1
Global AP User Name..... globalap
Global AP Dot1x User Name..... globalDot1x
```

This example shows how to display the authentication settings for a specific access point:

```
Device# show ap name AP02 config dot11 24ghz general
Cisco AP Identifier..... 0
Cisco AP Name..... TSIM_AP2
...
AP Dot1x User Mode..... AUTOMATIC
AP Dot1x User Name..... globalDot1x
```



## CHAPTER 55

# Converting Autonomous Access Points to Lightweight Mode

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- [Finding Feature Information, on page 893](#)
- [Guidelines for Converting Autonomous Access Points to Lightweight Mode, on page 893](#)
- [Information About Autonomous Access Points Converted to Lightweight Mode, on page 894](#)
- [How to Convert a Lightweight Access Point Back to an Autonomous Access Point, on page 896](#)
- [Disabling the Reset Button on Converted Access Points \(CLI\), on page 897](#)
- [Monitoring the AP Crash Log Information, on page 898](#)
- [How to Configure a Static IP Address on an Access Point, on page 898](#)
- [Configuring a Static IP Address on an Access Point \(GUI\), on page 900](#)
- [Recovering the Access Point Using the TFTP Recovery Procedure, on page 900](#)
- [Configuration Examples for Converting Autonomous Access Points to Lightweight Mode, on page 900](#)
- [Ethernet VLAN Tagging on Access Points, on page 901](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Guidelines for Converting Autonomous Access Points to Lightweight Mode

- Access points that are converted to lightweight mode do not support Wireless Domain Services (WDS). Converted access points communicate only with Cisco wireless LAN devices and cannot communicate with WDS devices. However, the device provides functionality that is equivalent to WDS when an access point is associated to it.

- All Cisco lightweight access points support 16 Basic Service Set Identifiers (BSSIDs) per radio and a total of 16 wireless LANs per access point. When a converted access point is associated to a device, only wireless LANs with IDs 1 through 16 are pushed to the access point, unless the access point is a member of an access point group.
- Access points that are converted to lightweight mode must get an IP address and discover the device using DHCP, DNS, or IP subnet broadcast.

## Information About Autonomous Access Points Converted to Lightweight Mode

You can convert autonomous Cisco Aironet access points to lightweight mode. When you upgrade the access points to lightweight mode, the access point communicates with the device and receives a configuration and software image from the device.

### Reverting from Lightweight Mode to Autonomous Mode

After you convert an autonomous access point to lightweight mode, you can convert the access point from a lightweight unit back to an autonomous unit by loading a Cisco IOS release that supports autonomous mode (Cisco IOS Release 12.3(7)JA or earlier releases). If the access point is associated with a device, you can use the device to load the Cisco IOS release. If the access point is not associated to a device, you can load the Cisco IOS release using TFTP. In either method, the access point must be able to access a TFTP server that contains the Cisco IOS release to be loaded.

### Using DHCP Option 43 and DHCP Option 60

Cisco Aironet Access Points use the type-length-value (TLV) format for DHCP option 43. You must program the DHCP servers to return the option based on the access point's DHCP Vendor Class Identifier (VCI) string (DHCP option 60).

See the product documentation for your DHCP server for instructions on configuring DHCP option 43. The [Converting Autonomous Access Points to Lightweight Mode](#) document contains example steps for configuring option 43 on a DHCP server.

If the access point is ordered with the Service Provider Option - AIR-OPT60-DHCP selected, the VCI string for that access point will be different than those strings listed in the previous table. The VCI string has the following suffix: ServiceProvider, for example, a 1260 with this option returns the VCI string Cisco AP c1260-ServiceProvider.



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**Note** Ensure that the device IP address that you obtain from the DHCP server is a unicast IP address. Do not configure the device IP address as a multicast address when configuring DHCP option 43.

---

#### Restrictions for DHCP Option 60

- Cisco Wave2 APs support strings with length up to 256 characters only.



---

**Note** When the string length exceeds the limit, the default value is sent during the DHCP discover process.

---

## How Converted Access Points Send Crash Information to the Device

When a converted access point unexpectedly reboots, the access point stores a crash file on its local flash memory at the time of the crash. After the unit reboots, it sends the reason for the reboot to the device. If the unit rebooted because of a crash, the device pulls up the crash file using existing CAPWAP messages and stores it in the device flash memory. The crash information copy is removed from the access point flash memory when the device pulls it from the access point.

## Uploading Memory Core Dumps from Converted Access Points

By default, access points converted to lightweight mode do not send memory core dumps to the device. This section provides instructions to upload access point core dumps using the device GUI or CLI.

## Displaying MAC Addresses for Converted Access Points

There are some differences in the way that controllers display the MAC addresses of converted access points on information pages in the controller GUI:

- On the **AP Summary** window, the controller lists the Ethernet MAC addresses of the converted access points.
- On the **AP Detail** window, the controller lists the BSS MAC addresses and Ethernet MAC addresses of the converted access points.
- On the Radio Summary page, the device lists converted access points by the radio MAC address.

## Configuring a Static IP Address for a Lightweight Access Point

If you want to specify an IP address for an access point rather than having one assigned automatically by a DHCP server, you can use the controller GUI or CLI to configure a static IP address for the access point. Static IP addresses are generally used only for deployments with a limited number of APs.

An access point cannot discover the device using domain name system (DNS) resolution if a static IP address is configured for the access point, unless you specify a DNS server and the domain to which the access point belongs. You can configure these parameters using either the device CLI or the GUI.



---

**Note** If you configure an access point to use a static IP address that is not on the same subnet on which the access point's previous DHCP address was, the access point falls back to a DHCP address after the access point reboots. If the access point falls back to a DHCP address, enter the **show ap config general Cisco\_AP** CLI command to show that the access point is using a fallback IP address. However, the GUI shows both the static IP address and the DHCP address, but it does not identify the DHCP address as a fallback address.

---

# How to Convert a Lightweight Access Point Back to an Autonomous Access Point

## Converting a Lightweight Access Point Back to an Autonomous Access Point (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device# enable	Enters privileged EXEC mode.
<b>Step 2</b>	<b>ap name Cisco_AP tftp-downgrade            tftp_server_ip_address            tftp_server_image_filename</b> <b>Example:</b> Device# ap name AP02 tftp-downgrade 10.0.0.1 tsrvname	Converts the lightweight access point back to autonomous mode.  <b>Note</b> After entering this command, you must wait until the access point reboots and then reconfigure the access point using the CLI or GUI.

## Converting a Lightweight Access Point Back to an Autonomous Access Point (Using the Mode Button and a TFTP Server)

### Procedure

- 
- Step 1** Configure the PC on which your TFTP server software runs with a static IP address in the range of 10.0.0.2 to 10.0.0.30.
- Step 2** Make sure that the PC contains the access point image file (such as *c1140-k9w7-tar.123-7.JA.tar* for a 1140 series access point) in the TFTP server folder and that the TFTP server is activated.
- Step 3** Rename the access point image file in the TFTP server folder to *c1140-k9w7-tar.default* for a 1140 series access point.
- Step 4** Connect the PC to the access point using a Category 5 (CAT5) Ethernet cable.
- Step 5** Disconnect power from the access point.
- Step 6** Press and hold the **MODE** button while you reconnect power to the access point.
- Note** The **MODE** button on the access point must be enabled.
- Step 7** Hold the **MODE** button until the status LED turns red (approximately 20 to 30 seconds), and release the **MODE** button.

- Step 8** Wait until the access point reboots as indicated by all the LEDs turning green followed by the Status LED blinking green.
- Step 9** After the access point reboots, reconfigure the access point using the GUI or the CLI.

## Disabling the Reset Button on Converted Access Points (CLI)

You can enable or disable the **Reset** button on access points that are converted to lightweight mode. The **Reset** button is labeled **MODE** on the outside of the access point.



**Note** The procedure to perform this task using the controller GUI is not currently available.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device# <code>enable</code>	Enters privileged EXEC mode.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>no ap reset-button</b> <b>Example:</b> Device(config)# <code>no ap reset-button</code>	Disables the <b>Reset</b> buttons on all converted access points that are associated to the device. <b>Note</b> To enable the <b>Reset</b> buttons on all the converted access points that are associated to the device, enter the <b>ap reset-button</b> command.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 5</b>	<b>ap name cisco_ap reset-button</b> <b>Example:</b> Device# <code>ap name AP02 reset-button</code>	Enables the <b>Reset</b> button on the converted access point that you specify.

# Monitoring the AP Crash Log Information



**Note** The procedure to perform this task using the device GUI is not currently available.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device# enable	Enters privileged EXEC mode.
<b>Step 2</b>	<b>show ap crash-file</b> <b>Example:</b> Device# show ap crash-file	Verifies whether the crash file is downloaded to the device.

# How to Configure a Static IP Address on an Access Point

## Configuring a Static IP Address on an Access Point (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device# enable	Enters privileged EXEC mode.
<b>Step 2</b>	<b>ap name Cisco_AP static-ip ip-address static_ap_address netmask static_ip_netmask gateway static_ip_gateway</b> <b>Example:</b> Device# ap name AP03 static-ip ip-address 9.9.9.16 netmask 255.255.0.0 gateway 9.9.9.2	Configures a static IP address on the access point. This command contains the following keywords and arguments: <ul style="list-style-type: none"> <li>• <b>ip-address</b>— Specifies the Cisco access point static IP address.</li> <li>• <b>ip-address</b>— Cisco access point static IP address.</li> <li>• <b>netmask</b>— Specifies the Cisco access point static IP netmask.</li> <li>• <b>netmask</b>— Cisco access point static IP netmask.</li> </ul>



	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>gateway</b>—Specifies the Cisco access point gateway.</li> <li>• <i>gateway</i>— IP address of the Cisco access point gateway.</li> </ul> <p>The access point reboots and rejoins the device, and the static IP address that you specify is pushed to the access point. After the static IP address has been sent to the access point, you can configure the DNS server IP address and domain name. You must perform Steps 3 and Step 4 after the access points reboot.</p>
<b>Step 3</b>	<b>enable</b> <b>Example:</b> Device# <code>enable</code>	Enters privileged EXEC mode.
<b>Step 4</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 5</b>	<b>ap static-ip name-server</b> <i>nameserver_ip_address</i> <b>Example:</b> Device(config)# <code>ap static-ip name-server</code>  10.10.10.205	Configures a DNS server so that a specific access point or all access points can discover the device using DNS resolution. <b>Note</b> To undo the DNS server configuration, enter the <b>no ap static-ip name-server nameserver_ip_address</b> command.
<b>Step 6</b>	<b>ap static-ip domain</b> <i>static_ip_domain</i> <b>Example:</b> Device(config)# <code>ap static-ip domain</code> domain1	Configures the domain to which a specific access point or all access points belong. <b>Note</b> To undo the domain name configuration, enter the <b>no ap static-ip domain static_ip_domain</b> command.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 8</b>	<b>show ap name</b> <i>Cisco_AP</i> <b>config general</b> <b>Example:</b> Device# <code>show ap name AP03 config general</code>	Displays the IP address configuration for the access point.

## Configuring a Static IP Address on an Access Point (GUI)

### Procedure

- 
- Step 1** Choose **Configuration > Wireless > Access Points**.
  - Step 2** On the **All Access Points** section, click on an **AP Name**.
  - Step 3** In the **Edit AP** window that is displayed, go to the **IP Config** section.
  - Step 4** Select the **Static IP (IPv4/IPv6)** check box. This activates the static IP details pane.
  - Step 5** Enter the **Static IP**, **Netmask**, **Gateway**, and **DNS IP Address**.
  - Step 6** Click **Update & Apply to Device**.
- 

## Recovering the Access Point Using the TFTP Recovery Procedure

### Procedure

- 
- Step 1** Download the required recovery image from Cisco.com (ap3g2-k9w8-tar.152-2.JA.tar) and install it in the root directory of your TFTP server.
  - Step 2** Connect the TFTP server to the same subnet as the target access point and power-cycle the access point. The access point boots from the TFTP image and then joins the device to download the oversized access point image and complete the upgrade procedure.
  - Step 3** After the access point has been recovered, you can remove the TFTP server.
- 

## Configuration Examples for Converting Autonomous Access Points to Lightweight Mode

### Example: Displaying the IP Address Configuration for Access Points

This example shows how to display the IP address configuration for an access point:

```
Device# show ap name AP03 dot11 24ghz config general
Cisco AP Identifier..... 4
Cisco AP Name..... AP6
IP Address Configuration..... Static IP assigned
IP Address..... 10.10.10.118
IP NetMask..... 255.255.255.0
Gateway IP Addr..... 10.10.10.1
```

```
Domain..... Domain1
Name Server..... 10.10.10.205
...
```

## Example: Displaying Access Point Crash File Information

This example shows how to display access point crash file information. Using this command, you can verify whether the file is downloaded to the device.

```
Device# show ap crash-file
Local Core Files:
lrad_AP1130.rdump0 (156)
```

The number in parentheses indicates the size of the file. The size should be greater than zero if a core dump file is available.

## Ethernet VLAN Tagging on Access Points

### Information About Ethernet VLAN Tagging on Access Points

You can configure VLAN tagging on the Ethernet interface either directly on the AP console or through the controller. The configuration is saved in the flash memory and all CAPWAP frames use the VLAN tag as configured, along with all the locally switched traffic, which is not mapped to a VLAN.

### Configuring Ethernet VLAN Tagging on Access Points (GUI)

#### Procedure

---

- Step 1** Choose **Configuration > Tags & Profiles > AP Join**.
  - Step 2** Click the name of the AP Join Profile or click **Add** to create a new one.
  - Step 3** In the **Add/Edit AP Join Profile** window that is displayed, click the **CAPWAP** tab and then click the **Advanced** tab.
  - Step 4** Check the **Enable VLAN Tagging** check box to enable VLAN tagging for the AP Join Profile.
  - Step 5** Click **Update & Apply to Device**.
- 

### Configuring Ethernet VLAN Tagging on Access Points (CLI)

Follow the procedure given below to configure Ethernet VLAN tagging on APs.

#### Before you begin

- VLAN tagging is not supported on MAPs that are in bridge mode. The feature is automatically disabled when the APs are set to bridge mode.
- If VLAN tagging is enabled, flex native VLAN ID cannot be configured for an AP.

- APs in flexconnect standalone mode (with VLAN tag enabled) may reload at every 10 minutes, if the APs fail to discover the wireless controller during failover.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>ap name</b> <i>ap-name</i> <b>vlan-tag</b> <i>vlan-id</i> <b>Example:</b> Device# ap name AP1 vlan-tag 12 Device# ap name AP1 no vlan-tag	Configures VLAN tagging for a non-bridge AP. Use the <b>no</b> form of this command to disable the configuration.
<b>Step 2</b>	<b>ap vlan-tag</b> <i>vlan-id</i> <b>Example:</b> Device# ap vlan-tag 1000 Device# ap no vlan-tag	Configure VLAN tagging for all nonbridge APs. Use the <b>no</b> form of this command to disable the configuration.
<b>Step 3</b>	<b>show ap config general</b> <b>Example:</b> Device# show ap config general	(Optional) Shows the common information of all the APs.



## CHAPTER 56

# Using Cisco Workgroup Bridges

- [Finding Feature Information](#), on page 903
- [Information About Cisco Workgroup Bridges and non-Cisco Workgroup bridges](#), on page 903
- [Monitoring the Status of Workgroup Bridges](#), on page 904
- [Debugging WGB Issues \(CLI\)](#), on page 904
- [Configuration Examples for Configuring Workgroup Bridges](#), on page 905

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Cisco Workgroup Bridges and non-Cisco Workgroup bridges

A WGB is a mode that can be configured on an autonomous Cisco IOS access point to provide wireless connectivity to a lightweight access point on behalf of clients that are connected by Ethernet to the WGB access point. A WGB connects a wired network over a single wireless segment by learning the MAC addresses of its wired clients on the Ethernet interface and reporting them to the lightweight access point using Internet Access Point Protocol (IAPP) messaging. The WGB provides wireless access connectivity to wired clients by establishing a single wireless connection to the lightweight access point.

When a Cisco WGB is used, the WGB informs the access points of all the clients that it is associated with. The device is aware of the clients that are associated with the access point. When non-Cisco WGBs are used, the device has no information about the IP address of the clients on the wired segment behind the WGB. Without this information, the device drops the following types of messages:

- ARP REQ from the distribution system for the WGB client.
- ARP RPLY from the WGB client.
- DHCP REQ from the WGB client.

- DHCP RPLY for the WGB client.

## Monitoring the Status of Workgroup Bridges



**Note** The procedure to perform this task using the device GUI is not currently available.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device# enable	Enters privileged EXEC mode.
<b>Step 2</b>	<b>show wireless wgb summary</b> <b>Example:</b> Device# show wireless wgb summary	Displays the WGBs on your network.
<b>Step 3</b>	<b>show wireless wgb mac-address wgb_mac_address detail</b> <b>Example:</b> Device# show wireless wgb mac-address 00:0d:ed:dd:25:82 detail	Displays the details of any wired clients that are connected to a particular WGB.

## Debugging WGB Issues (CLI)



**Note** The procedure to perform this task using the device GUI is not currently available.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device# enable	Enters privileged EXEC mode.
<b>Step 2</b>	<b>debug iapp all</b> <b>Example:</b> Device# debug iapp all	Enables debugging for IAPP messages.

	Command or Action	Purpose
<b>Step 3</b>	<b>debug iapp error</b> <b>Example:</b> Device# debug iapp error	Enables debugging for IAPP error events.
<b>Step 4</b>	<b>debug iapp packet</b> <b>Example:</b> Device# debug iapp packet	Enables debugging for IAPP packets.
<b>Step 5</b>	<b>debug mobility handoff [switch switch_number]</b> <b>Example:</b> Device# debug mobility handoff	Enables debugging for any roaming issues.
<b>Step 6</b>	<b>debug dhcp</b> <b>Example:</b> Device# debug dhcp	Debug an IP assignment issue when DHCP is used.
<b>Step 7</b>	<b>debug dot11 mobile</b> <b>Example:</b> Device# debug dot11 mobile	Enables dot11/mobile debugging. Debug an IP assignment issue when static IP is used.
<b>Step 8</b>	<b>debug dot11 state</b> <b>Example:</b> Device# debug dot11 state	Enables dot11/state debugging. Debug an IP assignment issue when static IP is used.

# Configuration Examples for Configuring Workgroup Bridges

## WGB Configuration: Example

This example shows how to configure a WGB access point using static WEP with a 40-bit WEP key:

```
Device# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Device(config)# dot11 ssid WGB_with_static_WEP
Device(config-ssid)# authentication open
Device(config-ssid)# guest-mode
Device(config-ssid)# exit
Device(config)# interface dot11Radio 0
Device(config)# station-role workgroup-bridge
Device(config-if)# encry mode wep 40
Device(config-if)# encry key 1 size 40 0 1234567890
Device(config-if)# ssid WGB_with_static_WEP
Device(config-if)# end
```

Verify that the WGB is associated to an access point by entering this command on the WGB:

**show dot11 association**

Information similar to the following appears:

```
Device# show dot11 associations
802.11 Client Stations on Dot11Radio0:
SSID [FCVTESTING] :
MAC Address      IP address      Device      Name      Parent      State
000b.8581.6aee  10.11.12.1     WGB-client  map1     -           Assoc
ap#
```





## CHAPTER 57

# Configuring Probe Request Forwarding

- [Finding Feature Information, on page 907](#)
- [Information About Configuring Probe Request Forwarding, on page 907](#)
- [How to Configure Probe Request Forwarding \(CLI\), on page 907](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Configuring Probe Request Forwarding

Probe requests are 802.11 management frames that are sent by clients to request information about the capabilities of Service Set Identifiers (SSIDs). By default, access points forward acknowledged probe requests to the device for processing. Acknowledged probe requests are probe requests for SSIDs that are supported by the access point. If desired, you can configure access points to forward both acknowledged and unacknowledged probe requests to the device. The device can use the information from unacknowledged probe requests to improve the location accuracy.

## How to Configure Probe Request Forwarding (CLI)



---

**Note** The procedure to perform this task using the device GUI is not currently available.

---

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wireless probe filter</b> <b>Example:</b> Device(config)# <code>wireless probe filter</code>	Enables or disables the filtering of probe requests forwarded from an access point to the device.  <b>Note</b> If you enable probe filtering, the default filter setting, the access point forwards only acknowledged probe requests to the device. If you disable probe filtering, the access point forwards both acknowledged and unacknowledged probe requests to the device.
<b>Step 3</b>	<b>wireless probe limit <i>num_probes interval</i></b> <b>Example:</b> Device(config)# <code>wireless probe limit 10 1000</code>	Limits the number of probe requests sent to the device per client per access point radio in a given interval. You must specify the following arguments with this command: <ul style="list-style-type: none"> <li>• <i>num_probes</i>—Number of probe requests forwarded to the device per client per access point radio in a given interval. The range is from 1 to 100.</li> <li>• <i>interval</i>—Probe limit interval in milliseconds. The range is from 100 to 10000.</li> </ul>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 5</b>	<b>show wireless probe</b> <b>Example:</b> Device# <code>show wireless probe</code>	Displays the advanced probe request configuration.



## CHAPTER 58

# Optimizing RFID Tracking

- [Finding Feature Information, on page 909](#)
- [Optimizing RFID Tracking on Access Points, on page 909](#)
- [How to Optimize RFID Tracking on Access Points, on page 909](#)
- [Configuration Examples for Optimizing RFID Tracking, on page 910](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Optimizing RFID Tracking on Access Points

To optimize the monitoring and location calculation of RFID tags, you can enable tracking optimization on up to four channels within the 2.4-GHz band of an 802.11b/g access point radio. This feature allows you to scan only the channels on which tags are usually programmed to operate (such as channels 1, 6, and 11).

## How to Optimize RFID Tracking on Access Points

### Optimizing RFID Tracking on Access Points (CLI)

#### Procedure

	Command or Action	Purpose
Step 1	<pre>ap name <i>Cisco_AP</i> mode monitor submode none</pre> <p>Example:</p>	Specifies the monitor submode for the access point as none.

	Command or Action	Purpose
	Device# ap name 3602a mode monitor submode none	<b>Note</b> A warning message indicates that changing the access point's mode will cause the access point to reboot and prompts you to specify whether you want to continue by entering <b>Y</b> .  After you enter <b>Y</b> , the access point reboots.
<b>Step 2</b>	<b>ap name Cisco_AP dot11 24ghz shutdown</b> <b>Example:</b> Device# ap name AP01 dot11 24ghz shutdown	Disables the access point radio.
<b>Step 3</b>	<b>ap name Cisco_AP monitor-mode tracking-opt</b> <b>Example:</b> Device# ap name TSIM_AP1 monitor-mode tracking-opt	Configures the access point to scan only the Dynamic Channel Assignment (DCA) channels supported by its country of operation.  <b>Note</b> To disable tracking optimization for an access point, enter the <b>ap name Cisco_AP monitor-mode tracking-opt no-optimization</b> command.
<b>Step 4</b>	<b>ap name Cisco_AP monitor-mode dot11b {fast-channel [first_channel second_channel third_channel fourth_channel]}</b> <b>Example:</b> Device# ap name AP01 monitor-mode dot11b  fast-channel 1 2 3 4	Chooses up to four specific 802.11b channels to be scanned by the access point.  <b>Note</b> In the United States, you can assign any value from 1 to 11 (inclusive) to the channel variable. Other countries support additional channels. You must assign at least one channel.
<b>Step 5</b>	<b>ap name Cisco_AP no dot11 24ghz shutdown</b> <b>Example:</b> Device# ap name AP01 no dot11 24ghz shutdown	Enables the access point radio.
<b>Step 6</b>	<b>show ap monitor-mode summary</b> <b>Example:</b> Device# show ap monitor-mode summary	Displays all the access points in monitor mode.

## Configuration Examples for Optimizing RFID Tracking

### Displaying all the Access Points in Monitor Mode: Example

This example shows how to display all the access points in monitor mode:

```
Device# show ap monitor-mode summary

AP Name          Ethernet MAC   Status   Scanning
                Channel
                List
-----
AP1131:4f2.9a 00:16:4:f2:9:a Tracking 1,6,NA,NA
```





## CHAPTER 59

# Country Codes

- [Finding Feature Information, on page 913](#)
- [Information About Country Codes, on page 913](#)
- [Prerequisites for Configuring Country Codes, on page 914](#)
- [Configuring Country Codes \(GUI\), on page 914](#)
- [How to Configure Country Codes , on page 915](#)
- [Configuration Examples for Configuring Country Codes, on page 917](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Country Codes

Controllers and access points are designed for use in many countries with varying regulatory requirements. The radios within the access points are assigned to a specific regulatory domain at the factory (such as -E for Europe), but the country code enables you to specify a particular country of operation (such as FR for France or ES for Spain). Configuring a country code ensures that each radio's broadcast frequency bands, interfaces, channels, and transmit power levels are compliant with country-specific regulations.

### Information About Japanese Country Codes

Country codes define the channels that can be used legally in each country. These country codes are available for Japan:

- JP—Allows only -J radios to join the controller
- J2—Allows only -P radios to join the controller
- J3—Uses the -U frequencies, but allows -U, -P, and -Q (other than 1550/1600/2600/3600) radios to join the WLC
- J4—Allows 2.4G JPQU and 5G PQU to join the controller.



---

**Note** The 1550, 1600, 2600, and 3600 APs require J4.

---

See the [Channels and Maximum Power Settings for Cisco Aironet Lightweight Access Points](#) document for the list of channels and power levels supported by access points in the Japanese regulatory domains.

## Prerequisites for Configuring Country Codes

- Generally, you should configure one country code per device; you configure one code that matches the physical location of the device and its access points. You can configure up to 20 country codes per device. This multiple-country support enables you to manage access points in various countries from a single device.
- When the multiple-country feature is used, all the devices that are going to join the same RF group must be configured with the same set of countries, configured in the same order.
- Access points are capable of using all the available legal frequencies. However, access points are assigned to the frequencies that are supported in their relevant domains.
- The country list configured on the RF group leader determines which channels the members will operate on. This list is independent of which countries have been configured on the RF group members.
- For devices in the Japan regulatory domain, you should have one or more Japan country codes (JP, J2, or J3) configured on your device at the time you last booted your device.
- For devices in the Japan regulatory domain, you must have at least one access point with a -J regulatory domain joined to your device.

## Configuring Country Codes (GUI)

### Procedure

---

- Step 1** Choose **Configuration > Wireless > Access Points > Country**.
- Step 2** On the **Country** page, select the check box for each country where your access points are installed. If you selected more than one check box, a message is displayed indicating that RRM channels and power levels are limited to common channels and power levels.
- Step 3** Click **Apply**.
-



# How to Configure Country Codes

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device# enable	Enters privileged EXEC mode.
<b>Step 2</b>	<b>show wireless country supported</b> <b>Example:</b> Device# show wireless country supported	Displays a list of all the available country codes.
<b>Step 3</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 4</b>	<b>ap dot11 24ghz shutdown</b> <b>Example:</b> Device(config)# ap dot11 5ghz shutdown	Disables the 802.11b/g network.
<b>Step 5</b>	<b>ap dot11 5ghz shutdown</b> <b>Example:</b> Device(config)# ap dot11 24ghz shutdown	Disables the 802.11a network.
<b>Step 6</b>	<b>ap country <i>country_code</i></b> <b>Example:</b> Device(config)# ap country IN	Assigns access points to a specific country. <b>Note</b> Make sure that the country code you choose is compatible with the regulatory domain of at least one of the access point's radios.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 8</b>	<b>show wireless country channels</b> <b>Example:</b> Device# show wireless country channels	Displays the list of available channels for the country codes configured on your device. <b>Note</b> Perform Steps 9 through 17 only if you have configured multiple country codes in Step 6.
<b>Step 9</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
Step 10	<b>no ap dot11 5ghz shutdown</b> <b>Example:</b> Device(config)# no ap dot11 5ghz shutdown	Enables the 802.11a network.
Step 11	<b>no ap dot11 24ghz shutdown</b> <b>Example:</b> Device(config)# no ap dot11 24ghz shutdown	Enables the 802.11b/g network.
Step 12	<b>end</b> <b>Example:</b> Device(config)# end	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
Step 13	<b>ap name cisco-ap shutdown</b> <b>Example:</b> Device# ap name AP02 shutdown	Disables the access point. <b>Note</b> Ensure that you disable only the access point for which you are configuring country codes.
Step 14	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
Step 15	<b>ap country country_code</b> <b>Example:</b> Device# ap country IN	Assigns an access point to a specific country. <b>Note</b> <ul style="list-style-type: none"> <li>• If you enabled the networks and disabled some access points and then enter the <b>ap country country_code</b> command, the specified country code is configured on only the disabled access points. All other access points are ignored.</li> <li>• Ensure that the country code that you choose is compatible with the regulatory domain of at least one of the access point's radios.</li> </ul>
Step 16	<b>end</b> <b>Example:</b> Device(config)# end	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

	Command or Action	Purpose
Step 17	<b>ap name <i>cisco-ap</i> no shutdown</b>  <b>Example:</b> Device# ap name AP02 no shutdown	Enables the access point.

# Configuration Examples for Configuring Country Codes

## Displaying Channel List for Country Codes: Example

This example shows how to display the list of available channels for the country codes configured on your device:

```

Device# show wireless country channels

Configured Country.....: US - United States
KEY: * = Channel is legal in this country and may be configured manually.
      A = Channel is the Auto-RF default in this country.
      . = Channel is not legal in this country.
      C = Channel has been configured for use by Auto-RF.
      x = Channel is available to be configured for use by Auto-RF.
      (-,-) = (indoor, outdoor) regulatory domain allowed by this country.
-----:+++++-----
802.11bg      :
Channels      :          1 1 1 1 1
              :          1 2 3 4 5 6 7 8 9 0 1 2 3 4
-----:+++++-----
(-A , -AB ) US : A * * * * A * * * * A . . .
Auto-RF       : . . . . .
-----:+++++-----
802.11a      :
Channels      :          1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
              :          3 3 3 4 4 4 4 4 5 5 6 6 0 0 1 1 2 2 2 3 3 4 4 5 5 6 6
              :          4 6 8 0 2 4 6 8 2 6 0 4 0 4 8 2 6 0 4 8 2 6 0 9 3 7 1 5
-----:+++++-----
(-A , -AB ) US : . A . A . A . A A A A A * * * * * . . . * * * A A A A *
Auto-RF       : . . . . .
-----:+++++-----
4.9GHz 802.11a :
Channels      :          1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2
              :          1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6
-----:+++++-----
US (-A , -AB ) : * * * * * * * * * * * * * * * * * * * * A * * * * * A
Auto-RF       : . . . . .
-----:+++++-----
    
```





## CHAPTER 60

# Configuring Link Latency

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- [Finding Feature Information, on page 919](#)
- [Prerequisites for Configuring Link Latency, on page 919](#)
- [Restrictions for Configuring Link Latency, on page 919](#)
- [Information About Configuring Link Latency, on page 920](#)
- [How to Configure Link Latency, on page 921](#)
- [How to Configure TCP MSS, on page 923](#)
- [Performing a Link Test \(CLI\), on page 924](#)
- [Configuration Examples for Configuring Link Latency, on page 924](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Configuring Link Latency

- The device displays the current round-trip time as well as a running minimum and maximum round-trip time. The minimum and maximum times continue to run as long as the device is up or can be cleared and allowed to restart.
- You can configure link latency for a specific access point using the device GUI or CLI or for all access points joined to the device using the CLI.

## Restrictions for Configuring Link Latency

- Link latency calculates the Control and Provisioning of Wireless Access Points (CAPWAP) response time between the access point and the device. It does not measure network latency or ping responses.

# Information About Configuring Link Latency

You can configure link latency on the device to measure the link between an access point and the device. You can use this feature with all access points that are joined to the device where the link can be a slow or unreliable WAN connection.

## TCP MSS

If the client's maximum segment size (MSS) in a Transmission Control Protocol (TCP) three-way handshake is greater than the maximum transmission unit can handle, the client might experience reduced throughput and the fragmentation of packets. To avoid this problem, you can specify the MSS for all access points that are joined to the device or for a specific access point.

When you enable this feature, the access point selects the MSS for TCP packets to and from wireless clients in its data path. If the MSS of these packets is greater than the value that you configured or greater than the default value for the CAPWAP tunnel, the access point changes the MSS to the new configured value.

## Link Tests

A link test is used to determine the quality of the radio link between two devices. Two types of link-test packets are transmitted during a link test: request and response. Any radio receiving a link-test request packet fills in the appropriate text boxes and echoes the packet back to the sender with the response type set.

The radio link quality in the client-to-access point direction can differ from that in the access point-to-client direction due to the asymmetrical distribution of the transmit power and receive sensitivity on both sides. Two types of link tests can be performed: a ping test and a CCX link test.

With the *ping link test*, the controller can test link quality only in the client-to-access point direction. The RF parameters of the ping reply packets received by the access point are polled by the controller to determine the client-to-access point link quality.

With the *CCX link test*, the device can also test the link quality in the access point-to-client direction. The device issues link-test requests to the client, and the client records the RF parameters (received signal strength indicator [RSSI], signal-to-noise ratio [SNR], and so on) of the received request packet in the response packet. Both the link-test requestor and responder roles are implemented on the access point and device. Not only can the access point or device initiate a link test to a CCX v4 or v5 client, but a CCX v4 or v5 client can initiate a link test to the access point or device.

The device shows the link-quality metrics for CCX link tests in both directions (out—the access point to the client; in—the client to the access point):

- Signal strength in the form of RSSI (minimum, maximum, and average)
- Signal quality in the form of SNR (minimum, maximum, and average)
- Total number of packets that are retried
- Maximum retry count for a single packet
- Number of lost packets
- Data rate of a successfully transmitted packet

The controller shows this metric regardless of direction:

- Link test request/reply round-trip time (minimum, maximum, and average)

The controller software supports CCX versions 1 through 5. CCX support is enabled automatically for every WLAN on the controller and cannot be disabled. The controller stores the CCX version of the client in its client database and uses it to limit the features for this client. If a client does not support CCXv4 or v5, the controller performs a ping link test on the client. If a client supports CCXv4 or v5, the controller performs a CCX link test on the client. If a client times out during a CCX link test, the controller switches to the ping link test automatically.

## How to Configure Link Latency

### Configuring Link Latency (CLI)

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device# <code>enable</code>	Enters privileged EXEC mode.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>ap link-latency</b> <b>Example:</b> Device(config)# <code>ap link-latency</code>	Enables link latency for all access points that are currently associated with the device.  <b>Note</b> To disable link latency for all the access points that are associated with the device, use the <b>no ap link-latency</b> command.  <b>Note</b> These commands enable or disable link latency only for access points that are currently joined to the device. You have to enable or disable link latency for the access points that join in the future.

	Command or Action	Purpose
		<p><b>Note</b> To enable or disable link latency for specific access points that are associated with the device, enter the following commands in Privileged EXEC mode:</p> <ul style="list-style-type: none"> <li>• <b>ap name <i>Cisco_AP</i> link-latency</b>—Enables link latency.</li> <li>• <b>ap name <i>Cisco_AP</i> no link-latency</b>—Disables link latency.</li> </ul>
<b>Step 4</b>	<p><b>ap tcp-adjust-mss size <i>size</i></b></p> <p><b>Example:</b></p> <pre>Device(config)# ap tcp-adjust-mss size 537</pre>	Configures TCP MSS adjust size for all access points. The range is from 536 to 1363.
<b>Step 5</b>	<p><b>show ap name <i>Cisco_AP</i> config general</b></p> <p><b>Example:</b></p> <pre>Device(config)# show ap name AP02 config general</pre>	<p>Displays the general configuration details of the access point. These configuration details contain the link latency results that correspond to the access point that you specify in the command.</p> <p>The output of this command contains the following link latency results:</p> <ul style="list-style-type: none"> <li>• <b>Current Delay</b>—The current round-trip time (in milliseconds) of CAPWAP heartbeat packets from the access point to the device and back.</li> <li>• <b>Maximum Delay</b>—Since the time that link latency has been enabled or reset, the maximum round-trip time (in milliseconds) of CAPWAP heartbeat packets from the access point to the device and back.</li> <li>• <b>Minimum Delay</b>—Since the time that link latency has been enabled or reset, the minimum round-trip time (in milliseconds) of CAPWAP heartbeat packets from the access point to the device and back.</li> </ul>
<b>Step 6</b>	<p><b>ap name <i>Cisco_AP</i> link-latency [reset]</b></p> <p><b>Example:</b></p> <pre>Device(config)# ap name AP02 link-latency reset</pre>	Clears the current, minimum, and maximum link latency statistics on the device for a specific access point.



	Command or Action	Purpose
<b>Step 7</b>	<b>show ap name <i>Cisco_AP</i> config general</b> <b>Example:</b> Device(config)# show ap name AP02 config general	Displays the general configuration details of the access point. Use this command to see the result of the reset operation.

# How to Configure TCP MSS

## Configuring TCP MSS (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>ap tcp-adjust-mss size <i>size_value</i></b> <b>Example:</b> Device(config)# ap tcp-adjust-mss size 537	Enables the TCP MSS on the particular access point that you specify.  <b>Note</b> To enable TCP MSS on all the access points that are associated with the device, enter the <b>ap tcp-adjust-mss size <i>size_value</i></b> command, where the size parameter is from 536 to 1363 bytes. The default value varies for different clients.
<b>Step 3</b>	<b>reload</b> <b>Example:</b> Device# reload	Reboots the device in order for your change to take effect.
<b>Step 4</b>	<b>show ap tcp-adjust-mss</b> <b>Example:</b> Device# show ap tcp-adjust-mss	Displays the current TCP MSS setting for all the access points that are associated with the device.  <b>Note</b> To display the TCP MSS settings that correspond to a specific access point, enter the <b>show ap name <i>Cisco_AP</i> tcp-adjust-mss</b> command.

## Performing a Link Test (CLI)



**Note** The procedure to perform this task using the device GUI is not currently available.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>test wireless linktest</b> <i>mac_address</i>  <b>Example:</b> Device# test wireless linktest 00:0d:88:c5:8a:d1	Runs a link test.
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>wireless linktest frame-size</b> <i>frame_size</i>  <b>Example:</b> Device(config)# wireless linktest frame-size 41	Configures the link test frame size for each packet.
<b>Step 4</b>	<b>wireless linktest number-of-frames</b> <i>number_of_frames</i>  <b>Example:</b> Device(config)# wireless linktest number-of-frames 50	Configures the number of frames to send for the link test.
<b>Step 5</b>	<b>end</b>  <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuration Examples for Configuring Link Latency

### Running a Link Test: Example

This example shows how to run a link test:

```
Device# test wireless linktest 6470.0227.ca55
Device# show wireless linktest statistic
```

```
Link Test to 64700227CA55 with 500 frame-size.
Client MAC Address                          : 6470.0227.ca55
AP Mac Address                              : 44e4.d901.19c0
```

```

Link Test Packets Sent           : 20
Link Test Packets Received      : 20
Link Test Pkts Lost (Total/AP->Clnt/Clnt->AP) : 0/0/0
Link Test Pkts round trip time (min/max/avg) : 9ms/31ms/14ms
RSSI at AP (min/max/average)    : -53dBm/-51dBm/-52dBm
RSSI at Client (min/max/average) : -48dBm/-40dBm/-44dBm

```

## Displaying Link Latency Information: Example

This example shows how to display general configuration details of the access point. These configuration details contain the link latency results that correspond to the access point that you specify in the command.

```

Device# show ap name AP01 config general

Cisco AP Name           : AP01
Cisco AP Identifier     : 55
Country Code           : US - United States
Regulatory Domain Allowed by Country : 802.11bg:-A      802.11a:-A
AP Country Code        : US - United States
AP Regulatory Domain    : Unconfigured
Switch Port Number     : Tel/0/1
MAC Address             : 0000.2000.03f0
IP Address Configuration : Static IP assigned
IP Address              : 9.9.9.16
IP Netmask              : 255.255.0.0
Gateway IP Address     : 9.9.9.2
Fallback IP Address Being Used : 9.9.9.16
Domain                 : Cisco
Name Server            : 0.0.0.0
CAPWAP Path MTU       : 1485
Telnet State           : Enabled
SSH State              : Disabled
Cisco AP Location     : default-location
Cisco AP Group Name    : default-group
Primary Cisco Controller Name : CAPWAP Controller
Primary Cisco Controller IP Address : 9.9.9.2
Secondary Cisco Controller Name :
Secondary Cisco Controller IP Address : Not Configured
Tertiary Cisco Controller Name :
Tertiary Cisco Controller IP Address : Not Configured
Administrative State   : Enabled
Operation State       : Registered
AP Mode               : Local
AP Submode            : Not Configured
Remote AP Debug        : Disabled
Logging Trap Severity Level : informational
Software Version      : 7.4.0.5
Boot Version          : 7.4.0.5
Stats Reporting Period : 180
LED State             : Enabled
PoE Pre-Standard Switch : Disabled
PoE Power Injector MAC Address : Disabled
Power Type/Mode       : Power Injector/Normal Mode
Number of Slots       : 2
AP Model              : 3502E
AP Image              : C3500-K9W8-M
IOS Version           :
Reset Button          :
AP Serial Number      : SIM1140K002
AP Certificate Type    : Manufacture Installed
Management Frame Protection Validation : Disabled
AP User Mode          : Customized

```

```

AP User Name : Not Configured
AP 802.1X User Mode : Not Configured
AP 802.1X User Name : Not Configured
Cisco AP System Logging Host : 255.255.255.255
AP Up Time : 16 days 3 hours 14 minutes 1 s
econd
AP CAPWAP Up Time : 33 minutes 15 seconds
Join Date and Time : 01/02/2013 22:41:47
Join Taken Time : 16 days 2 hours 40 minutes 45
seconds
Join Priority : 1
Ethernet Port Duplex : Auto
Ethernet Port Speed : Auto
AP Link Latency : Enabled
Current Delay : 0
Maximum Delay : 0
Minimum Delay : 0
Last Updated (based on AP up time) : 0 seconds
Rogue Detection : Disabled
AP TCP MSS Adjust : Disabled
AP TCP MSS Size : 536

```

## Displaying TCP MSS Settings: Example

This example shows how to display the current TCP MSS setting for all the access points that are associated with the device:

```
Device# show ap tcp-adjust-mss
```

AP Name	TCP State	MSS Size
AP01	Disabled	6146
AP02	Disabled	536
AP03	Disabled	6146
AP04	Disabled	6146
AP05	Disabled	6146



# CHAPTER 61

## Configuring Power over Ethernet

- [Finding Feature Information, on page 927](#)
- [Information About Configuring Power over Ethernet, on page 927](#)
- [How to Configure Power over Ethernet, on page 927](#)
- [Configuration Examples for Configuring Power over Ethernet, on page 928](#)

### Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

### Information About Configuring Power over Ethernet

When an access point that has been converted to lightweight mode (such as an AP1262) access point is powered by a power injector that is connected to a Cisco pre-Intelligent Power Management (pre-IPM) switch, you must configure Power over Ethernet (PoE), which is also known as *inline power*.

### How to Configure Power over Ethernet

#### Configuring Power over Ethernet (CLI)

##### Procedure

	Command or Action	Purpose
Step 1	<b>ap name</b> <i>Cisco_AP</i> <b>power injector installed</b>  <b>Example:</b>	Enables the PoE power injector state. The access point remembers that a power injector is connected to this particular switch port. If you relocate the access point, you must reenter

	Command or Action	Purpose
	<pre>Device# ap name AP02 power injector installed</pre>	<p>this command after the presence of a new power injector is verified.</p> <p><b>Note</b> Enter this command if your network contains any older Cisco 6-W switches that could be accidentally overloaded if connected directly to a 12-W access point. Make sure that the Cisco Discovery Protocol (CDP) is enabled before entering this command. Otherwise, this command will fail.</p>
<b>Step 2</b>	<p><b>ap name <i>Cisco_AP</i> power injector override</b></p> <p><b>Example:</b></p> <pre>Device# ap name AP02 power injector override</pre>	<p>Removes the safety checks and allows the access point to be connected to any switch port. You can use this command if your network does not contain any older Cisco 6-W switches that could be overloaded if connected directly to a 12-W access point. The access point assumes that a power injector is always connected. If you relocate the access point, it continues to assume that a power injector is present.</p>
<b>Step 3</b>	<p><b>ap name <i>Cisco_AP</i> power injector switch-mac-address <i>switch_mac_address</i></b></p> <p><b>Example:</b></p> <pre>Device# ap name AP02 power injector switch-mac-address 10a.2d.5c.3d</pre>	<p>Sets the MAC address of the switch port that has a power injector.</p> <p><b>Note</b> Enter this command if you know the MAC address of the connected switch port and do not want to automatically detect it using the installed option.</p>
<b>Step 4</b>	<p><b>show ap name <i>Cisco_AP</i> config general</b></p> <p><b>Example:</b></p> <pre>Device# show ap name AP02 config general</pre>	<p>Displays common information that includes the PoE settings for a specific access point.</p> <p><b>Note</b> The Power Type/Mode text box shows “degraded mode” if the access point is not operating at full power.</p>

## Configuration Examples for Configuring Power over Ethernet

### Displaying Power over Ethernet Information: Example

This example shows how to display common information that includes the PoE settings for a specific access point:

```
Device# show ap name AP01 config general
```

```
Cisco AP Identifier..... 1
Cisco AP Name..... AP1
...
PoE Pre-Standard Switch..... Enabled
PoE Power Injector MAC Addr..... Disabled
Power Type/Mode..... PoE/Low Power (degraded mode)
...
```







## PART **X**

# Mobility

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- [Mobility Network Elements, on page 939](#)
- [Mobility Control Protocols, on page 943](#)
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## CHAPTER 62

# Information About Mobility

- [Overview, on page 933](#)
- [Wired and Wireless Mobility, on page 934](#)
- [Features of Mobility, on page 934](#)
- [Sticky Anchoring for Low Latency Roaming, on page 936](#)
- [Bridge Domain ID and L2/L3 Roaming, on page 936](#)
- [Link Down Behavior, on page 936](#)
- [Platform Specific Scale Requirement for the Mobility Controller, on page 937](#)

## Overview

The delivers more services at access layer other than merely providing increased speeds and feeds. Wireless services is now integrated with the switch, which ensures that the access layer switch terminates the wireless users data plane, thereby delivering on the promise of Cisco's unified architecture. Unification implies that mobility services are provided to both wireless and wired stations.

The provides seamless roaming, which requires transparency of the network configuration and deployment options to the client.

From the end user's perspective, any mobility event must not change its IP address, its default router or DHCP server. This means that as stations roam, they must be able to

- Send an ARP to their default router, or
- Transmit a DHCP request to the server that had previously assigned their address.

From the infrastructure's perspective, as mobility events occur, the station's traffic must follow its current point of attachment, which can either be a mobility agent (MA) or mobility controller (MC). This must be true regardless of whether the station has moved to a network that is configured for a different subnet. The period from which the station is not receiving traffic following its mobility event must be as short as possible, even below 40 ms whenever possible, which includes any authentication procedures that are required.

From the infrastructure's perspective, the mobility management solution must have four main components, and all of these functions must be performed within the constraints of roaming:

- Initial Association—This function is used to identify the user's new point of attachment in the network.
- Context Transfer—This function is used to transfer state information associated with the station. This ensures that the station's static and real-time policies, including security and application ACLs, and services, remain the same across handoffs.

- **Handoff**—This function is used to signal that the station's point of attachment has changed, and control of the station should be relinquished by the previous access .
- **Data Plane**—This function is typically tied to the handoff process, and ensures that the station's traffic continues to be delivered and received from the station without any noticeable performance degradation.




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**Note** To form a mobility tunnel between Cisco Catalyst 4500E Supervisor Engine 8-E and the Cisco Unified Wireless Controller, you should match the wireless management interface's VLAN with the VLAN on the uplink interface.

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**Caution** If you have configured virtual routing and forwarding (VRF) on wireless management interface VLAN, the mobility feature may not work expected.

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**Note** You must enable PIM, IP ROUTING and IP MULTICAST Routing for wireless mobility multicast to work.

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## Wired and Wireless Mobility

One of the key features of the Converged access solution (applicable to both the Cisco Catalyst 3850 Switch and Cisco WLC 5700 Series Controller) is its ability to provide a device with an IP address and maintain its session persistence, across mobility events from ethernet connections to wireless and vice-versa. This feature allows users to remain on an ethernet network when possible, and make use of the freedom of mobility associated with wireless when necessary.

This feature leverages support from both the client and the infrastructure and uses the two factor authentication-device and user. The device authentication credentials is cached in the mobility controller (MC). When a device transitions across link layers, the device credentials is validated, and if a match is found, the MC ensures that the same IP address is assigned to the new interface.

## Features of Mobility

- **Mobility Controller (MC)**—The controller provides mobility management services for inter-peer group roaming events. The MC provides a central point of contact for management and policy based control protocols, such as RADIUS. This eliminates the need for the infrastructure servers to maintain a user's location as it transitions throughout the network. The MC sends the configuration to all the mobility agents under its sub-domain of their mobility configuration, peer group membership and list of members. A sub-domain is synonymous to the MC that forms it. Each sub-domain consists of an MC and zero or more access switches that have AP's associated to them.
- **Mobility Agents (MA)**— A mobility agent is either an access switch that has a wireless module running on it or an MC with an internal MA running on it. A mobility agent is the wireless component that maintains client mobility state machine for a mobile client that is connected via an AP to the device that the MA is running on.

- **Mobility Sub Domain**— It is an autonomous portion of the mobility domain network. A mobility sub-domain comprises of a single mobility controller and its associated mobility agents (MAs).



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**Note** Even when more than one mobility controller is present, only one MC can be active at any given time.

---

A mobility sub-domain is the set of devices managed by the active mobility controller. A mobility sub-domain comprises of a set of mobility agents and associated access points.

- **Mobility Group**— A collection of mobility controllers (MCs) across which fast roaming is supported. The concept of mobility group is the same as a collection of buildings in a campus across which frequent roaming is expected.
- **Mobility Domain**— A collection of mobility sub-domains across which mobility is supported. The term mobility domain may be the same as a campus network.
- **Mobility Oracle (MO)**—The mobility oracle acts as the point of contact for mobility events that occur across mobility sub-domains. It also maintains a local database of each station in the entire mobility domain, their home and current sub-domain. A mobility domain includes one or more mobility oracle, though only one would be active at any given time.
- **Mobility Tunnel Endpoint (MTE)**— The mobility tunnel endpoint (MTE) provides data plane services for mobile devices through the use of tunneling. This minimizes the impact of roaming events on the network by keeping the user's point of presence on the network a constant.
- **Point of Attachment**— A station's point of attachment is where its data path is initially processed upon entry in the network. This could either be the access switch that is currently providing it service, or the wireless LAN controller.
- **Point of Presence**— A station's point of presence is the place in the network where the station is being advertised. For instance, if an access switch is advertising reachability to the station via a routing protocol, the interface on which the route is being advertised is considered the station's point of presence.
- **Switch Peer Group (SPG)**— A peer group is a statically created list of neighboring access switches between which fast mobility services is provided. A peer group limits the scope of interactions between switches during handoffs to only those that are geographically proximate.
- **Station**—A user's device that connects to and requests service from the network. The device may have a wired, wireless or both interfaces.
- **Switch in the same SPG**—A peer switch that is part of the peer group of the local switch.
- **Switch outside the SPG**—A peer access switch that is not part of the local switch's peer group.
- **Foreign Mobility Controller**— The mobility controller providing mobility management service for the station in a foreign mobility sub-domain. The foreign mobility controller acts as a liaison between access switches in the foreign sub-domain and the mobility controller in the home domain.
- **Foreign Mobility Sub-Domain**— The mobility sub-domain, controlled by a mobility controller, supporting a station which is anchored in another mobility sub-domain
- **Foreign Switch**— The access switch in the foreign mobility sub-domain currently providing service to the station.

- Anchor Mobility Controller— The mobility controller providing a single point of control and mobility management service for stations in their home mobility sub-domain.
- Anchor Mobility Sub-Domain— The mobility sub-domain, controlled by a mobility controller, for a station where its IP address was assigned.
- Anchor Switch— The switch in the home mobility sub-domain that last provided service to a station.

## Sticky Anchoring for Low Latency Roaming

Sticky Anchoring ensures low roaming latency from the client's point of presence is maintained at the switch where the client initially joins the network. It is expensive to apply client policies at a switch for a roaming client. There can be considerable delay as it involves contacting the AAA server for downloadable ACLs which is not acceptable for restoring time sensitive client traffic.

To manage this delay, when the client roams between APs connected to different switches, irrespective of whether it is an intra sub-domain roam or inter sub-domain roam, the client traffic is always tunneled to the switch where the client first associates. The client is anchored at its first point of attachment for its lifetime in the network.

This behavior is enabled by default. You can also disable this behavior to allow the client anchoring only for inter-subnet roams. This configuration is per WLAN config and is available under the WLAN config mode. The customer can configure different SSIDs for time sensitive and non time sensitive applications.

## Bridge Domain ID and L2/L3 Roaming

Bridge domain ID provides the mobility nodes with information to decide on specific roam type, either as L2 or L3 roam. It also allows the network administrators to reuse the VLAN IDs across network distribution. When the VLAN IDs do not have the associated subnet configurations, they may require additional parameter to use in conjunction with VLAN ID. The network administrator ensures that the given VLAN under the same bridge domain ID are associated with the unique subnet. The mobility nodes will first check for the bridge domain ID for the given node and the VLAN ID associated with the client to identify the roam type. The bridge domain ID and the VLAN ID must be same to treat a roam as L2 roam.

The bridge domain ID is configured for each SPG when creating a SPG and later on the MC. The bridge domain ID could be same for more than one SPG and all the MAs under the SPG will share the same bridge domain ID. This information is pushed to the MAs as part of the configuration download when MA comes up initially. If the bridge domain ID is modified when the system is up, it will be pushed to all the MAs in the modified SPG and will take immediate effect for the future roams.

## Link Down Behavior

This section provides information about data synchronization between MA-MC and MC-MO when MC or MO faces downtime in absence of redundancy manager. When Keepalive is configured between MA-MC or MC-MO the clients database is synchronized between the MO and the MCs and the MC and its MAs respectively.

## Platform Specific Scale Requirement for the Mobility Controller

The Mobility Controller (MC) role is supported on a number of different platforms like, the Cisco WLC 5700 Series, CUWN and Catalyst 3850 Switches. The scale requirements on these three platforms are summarized in the table below:

Scalability	Catalyst 3850 as MC	Catalyst 3650 as MC	Cisco WLC 5700 as MC	CUWN 5508 as MC	WiSM2 as MC
Max number of MC in Mobility Domain	8	8	72	72	72
Max number of MC in Mobility Group	8	8	24	24	24
Max number of MAs in Sub-domain (per MC)	16	16	350	350	350
Max number of SPGs in Sub-domain (per MC)	8	8	24	24	24
Max number of MAs in a SPG	16	16	64	64	64







## CHAPTER 63

# Mobility Network Elements

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- [Mobility Agent, on page 939](#)
- [Mobility Controller, on page 940](#)
- [Mobility Oracle, on page 941](#)
- [Guest Controller, on page 941](#)

## Mobility Agent

A Mobility Controller resides on the switch. It is both, control path and data path entity and is responsible for:

- Handling the mobility events on the switch
- Configuring the datapath elements on the switch for mobility, and
- Communicating with the mobility controller

As MA, the device performs the datapath functions by terminating the CAPWAP tunnels that encapsulate 802.11 traffic sourced by wireless stations.

This allows the device to apply features to wired and wireless traffic in a uniform fashion. As far as device is concerned, 802.11 is just another access medium.

The MA performs the following functions:

- Support the mobility protocol – The MA is responsible for responding in a timely manner, ensuring the device is capable of achieving its roaming budget.
- Point of presence – If the wireless subnets are not available at the MC, the MA assumes the point of presence if the wireless client VLAN is not available at the new point of attachment and tunnel the client traffic accordingly.
- ARP Server – When the network is configured in a layer 2 mode, the MA is responsible for advertising reachability for the stations connected to it. If tunneling is employed, the ARP request is transmitted on behalf of the station through the tunnel, which the point of presence (anchor switch) would bridge onto its uplink interface.
- Proxy IGMP – The MA on the device is responsible for subscribing to multicast groups on behalf of a station after a roaming event has occurred. This information is passed as part of the context to the new device. This ensures the multicast flows follow the user as it roams.
- Routing – When the device is connected to a layer 3 access network, the MA is responsible for injecting routes for the stations that are associated with it for which tunneling is not provided.

- 802.1X Authenticator – The authenticator function is included in the MA, and handles both wired and wireless stations.
- Secure PMK Sharing – When a station successfully authenticates to the network, the MA forwards the PMK to the MC. The MC is responsible for flooding the PMK to all the MAs under its sub-domain and to the peer MCs in the mobility group.

The MA also performs the following datapath functions:

- Mobility tunnel – If tunneling is used, the MA encapsulates and decapsulates packets from the mobility tunnel to the MC, and to other MA in the peer group, if the access switches are serving as points of presence. The MA supports the tunneling of client data traffic between the point of attachment and the point of attachment. The packet format used for other switches is CAPWAP with an 802.3 payload. The MA also supports reassembly and fragmentation for mobility tunnels.
- Encryption – The mobility control traffic between the mobility nodes is DTLS encrypted. The MA also encrypts the CAPWAP control and data (optional) at the point of attachment.
- CAPWAP – The device supports the CAPWAP control and data planes. The device forwarding logic is responsible for terminating the CAPWAP tunnels with 802.11 as well as 802.3 payloads. Since support for large frames (greater than 1500bytes) is not universally available, the device supports CAPWAP fragmentation and reassembly.




---

**Note** Mobility tunnel path via an L3 interface on the 4500 or the L3 interface on the uplink port is not supported. It is not possible to have an L3 wireless management interface. Even if the tunnel comes up, packet forwarding is not possible as it is not supported. 4510 drops DHCP packets from wireless clients if SSID is anchored to a different Cisco WLC.

---

## Mobility Controller

The main function of mobility controller is to coordinate the client roaming beyond a switch peer group. The other features of the mobility controller are:

- Station Database—The Mobility Controller maintains a database of all the clients that are connected within the local mobility sub-domain.
- Mobility Protocol—The MC supports the mobility protocol which ensures the target roaming point responds in a timely manner and achieves the 150ms roaming budget
- Interface to Mobility Oracle—The Mobility Controller acts as a gateway between the and the Mobility Oracle. When the Mobility Controller does not find a match in its local database, it suggests a match for a wireless client entry (in its database) and forwards the request to the Mobility Oracle, which manages the Mobility Domain.




---

**Note** Mobility Oracle function can be enabled on an MC only if it is supported by the platform.

---

- ARP Server—When tunneling is employed for a station, its point of presence on the network is the Mobility Tunnel Endpoint (MTE). The Mobility Controller responds to any ARP requests received for the stations it is responsible for.
- Routing—When the Mobility Controller is connected to a layer three network, the Mobility Controller is responsible for injecting routes for the stations it supports into the network.
- Configures MTE—The Mobility Controller is the control point for the for all mobility management related requests. When a change in a station's point of attachment occurs, the Mobility Controller is responsible for configuring the forwarding policy on the MTE.
- NTP Server—The Mobility Controller acts as an NTP server to the and supports all the nodes to have their clocks synchronized with it.



---

**Note** The Cisco 5700 series WLC and other controller platforms that have the Mobility Controller function enabled by default should not be added to a switch peer group (SPG).

---

## Mobility Oracle

The Mobility Oracle coordinates the client roams beyond the subdomain on a need basis and consists of the following features:

- Station Database—The Mobility Oracle maintains a database of all stations that are serviced within the mobility domain. This database is populated during the Mobility Oracle's interactions with all the Mobility Controllers, in all of the mobility sub-domains it supports.
- Interface to Mobility Controller—When the Mobility Oracle receives a request from a Mobility Controller, it performs a station lookup, and forwards, whenever needed, the request to the proper Mobility Controller.
- NTP Server—The Mobility Oracle acts as an NTP server to the Mobility Controllers and synchronizes all the clocks within the mobility domain.

## Guest Controller

The guest access feature provides guest access to wireless clients. The guest tunnels use the same format as the mobility tunnels. Using the guest access feature, there is no need to configure guest VLANs on the access switch. Traffic from the wired and wireless clients terminates on Guest Controller. Since the guest VLAN is not present on the access switch, the traffic is tunneled to the MTE over the existing mobility tunnel, and then via a guest tunnel to the Guest Controller.

The advantage of this approach is that all guest traffic passes through the MTE before it is tunneled to the Guest Controller. The Guest Controller only needs to support tunnels between itself and all the MTEs.

The disadvantage is that the traffic from the guest client is tunneled twice - once to the MTE and then again to the Guest Controller.

Clients cannot roam to Guest Controllers because roaming is not supported on Guest Controllers. This restriction is applicable only for the IOS-XE guest anchor, and not for AireOS.





## CHAPTER 64

# Mobility Control Protocols

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- [Initial Association and Roaming, on page 943](#)
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- [Intra Switch Handoff, on page 945](#)
- [Intra Switch Peer Group Handoff, on page 945](#)
- [Inter Switch Peer Group Handoff, on page 946](#)
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- [Inter Mobility Group Handoff, on page 949](#)

## About Mobility Control Protocols

The mobility control protocol is used regardless of whether tunneled or routed. The mobility control protocol is used for mobility events between the MO, MC and MA.

The mobility architecture uses both,

- Distributed approach, using the direct communication with the switches in their respective SPG, as well as
- Centralized approach, using the MC and MO.

The goal is to reduce the overhead on the centralized MC, while limiting the interactions between switches to help scale the overall system.

## Initial Association and Roaming

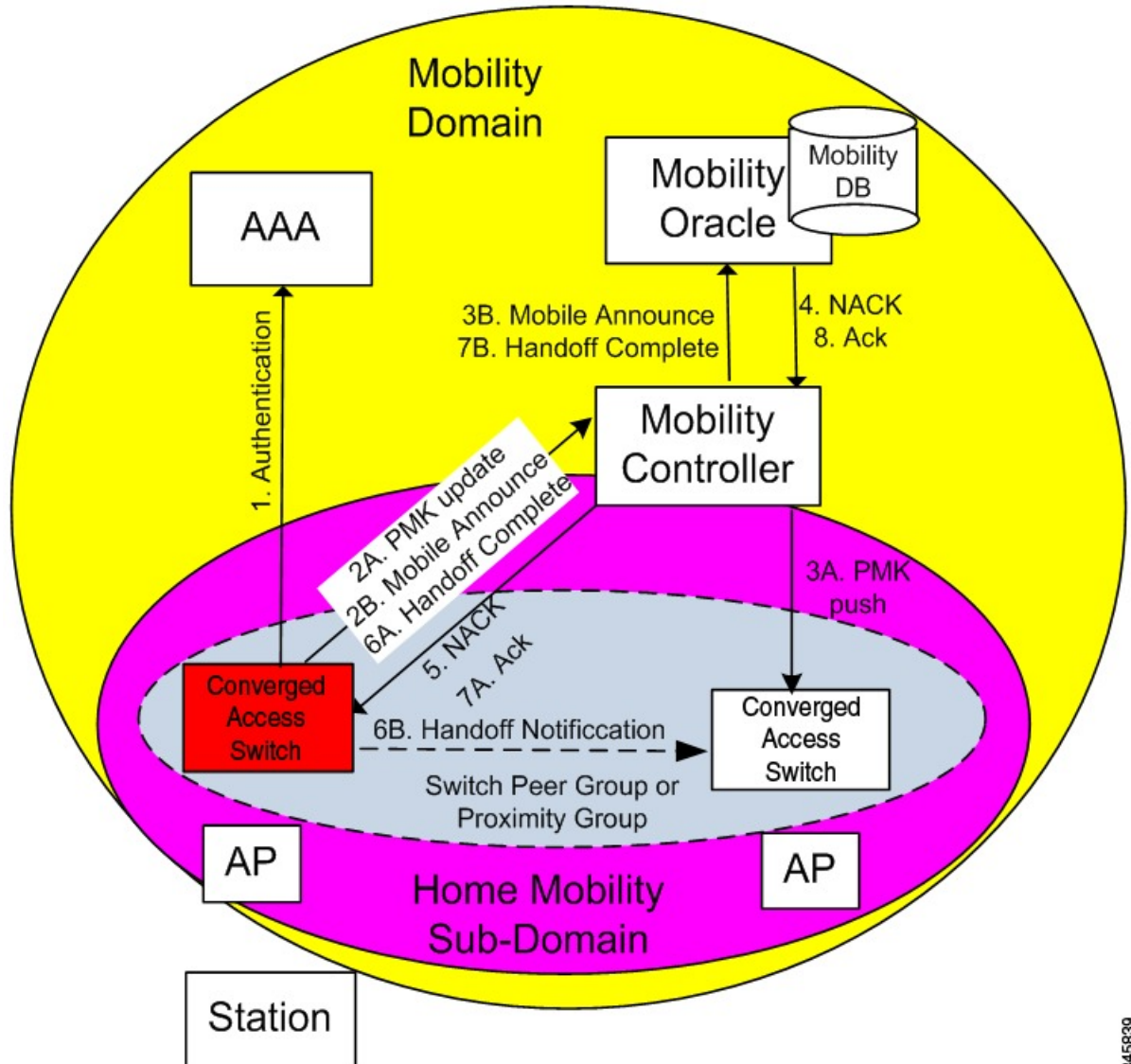
The following scenarios are applicable to the mobility management protocol:

- Initial Association
- Intra Switch Roam
- Intra Switch Peer Group Roam
- Inter Switch Peer Group Roam
- Inter Sub-Domain Roam
- Inter Group Roam

# Initial Association

The illustration below explains the initial association process followed by the device:

Figure 71: Initial Association



1. When a station initially associates with a mobility agent, the MA performs a lookup to determine whether keying information for key caching is locally available in the MA. If no keying information is available, which is the case when the station first appears in the network, the device prompts the device to authenticate itself to generate the Pairwise Master Key (PMK). The PMK is generated on the client and the RADIUS server side, and the RADIUS server forwards the PMK to the authenticator, the MA.
2. The MA sends the PMK to the MC.
3. After receiving the PMK from the MA, the MC transmits the PMK to all the MAs in its sub-domain, and to all the other MCs in its mobility group.

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4. The mobility group is a single key domain. This ensures that 802.11r compliant stations recognize the key domain, and attempts to utilize the fast transition procedures defined in 802.11r.




---

**Note** The 802.11r protocol defines a key domain, which is a collection of access points that share keying information.

---

5. (Refer to step 2B in the illustration). Since the station is new to the mobility sub-domain, as indicated by the fact that the PMK is not in the MA local key cache, the MA transmits a mobile announce message to the MC.
6. The MC checks if the client exists in its database. As the client cannot be found, the MC in turn forwards it to the MO, if available.
7. (Refer to step 5 in the illustration). As the station is new to the network, the MO returns a negative response (NACK), which is forwarded by the MC to the device. If the Mobility Oracle is not available then the MC is responsible for not responding to the Mobile Announce.




---

**Note** In new mobility if there are many peers, the IOS controller will not react on a NACK message from the AirOS peer and sends two more probes. NACK is ignored if the client is not present it just drops it, in such a scenario AIREOS sends the NACK. So NACK from mobility controller is not processed.

---

8. The MA on the device informs the MC about the station's new point of attachment via the Handoff Complete message.
9. The MA then informs the other MAs in its switch peer group (SPG) about the station's new point of attachment via the Handoff Notification message. It is necessary to transmit this notification to the MAs in its SPG to allow local handoff without interacting with the MC. The Handoff Notification message sent to MAs in SPG need not carry all the information in Handoff Complete message sent to the MC.
10. (Refer to step 7B in the illustration). The MC updates its database and forwards the Handoff Complete message to the Mobility Oracle. This ensures that the Mobility Oracle's database is updated to record the station's current home mobility sub-domain.

To eliminate race conditions that could occur with devices moving quickly across device, regardless of whether they are within a mobility sub-domain or not, the messages between MA and MC/MO are time synchronized. This would allow the MC and MO to properly process requests, if they are received out of order.

The Handoff Notification sent to MAs in the SPG are not acknowledged.

## Intra Switch Handoff

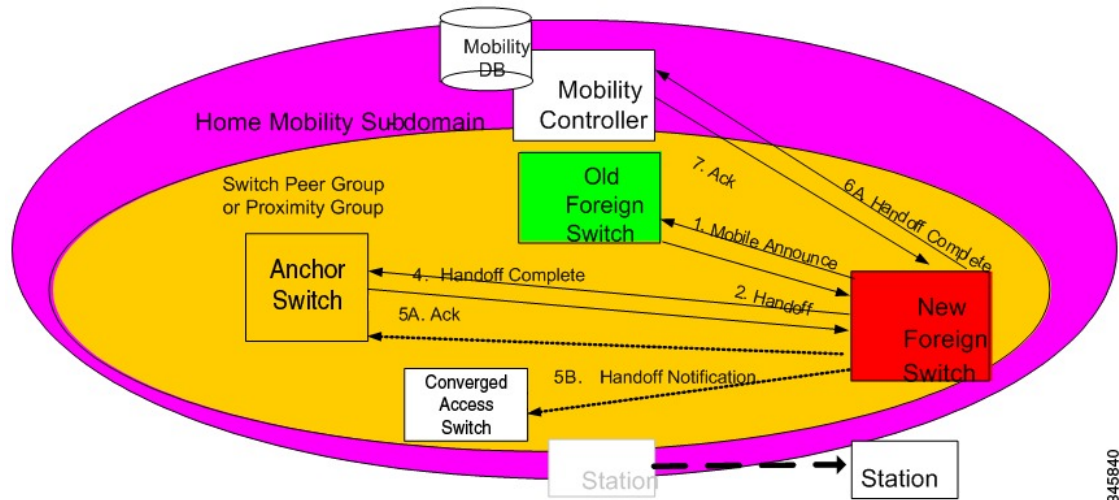
Mobility events within an MA are completely transparent to the SPG and the MC. When a station moves across APs on the same MA and attempts to perform a fast handoff, the PMK is present on the MA. The MA will complete the fast handoff without invoking any additional signal.

## Intra Switch Peer Group Handoff

The switch peer group (SPG) is a group of MAs between which users may roam, and expect fast roaming services. Allowing the MA to handoff directly within a SPG reduces the overhead on the MC as it requires fewer messages to be exchanged.

After the initial association is complete the station moves to another MA belonging to its SPG. In an intra switch peer group roam, the initial association, the stations PMK was forwarded to all MAs in the mobility sub-domain.

Figure 72: Intra Switch Peer Group Handoff



The following process explains the intra switch peer group handoff:

1. In the initial association example, the Handoff Notification message is sent to all MAs in its SPG to know the station's current point of attachment.
2. The new MA sends a unicast Mobile Announce message to the previous MA to which the client is associated.
3. After the handoff completion, the new MA transmits a Handoff Complete message to the MC.
4. The new device sends a Handoff Notification to all MA in its own SPG to inform them about the clients new point of presence.

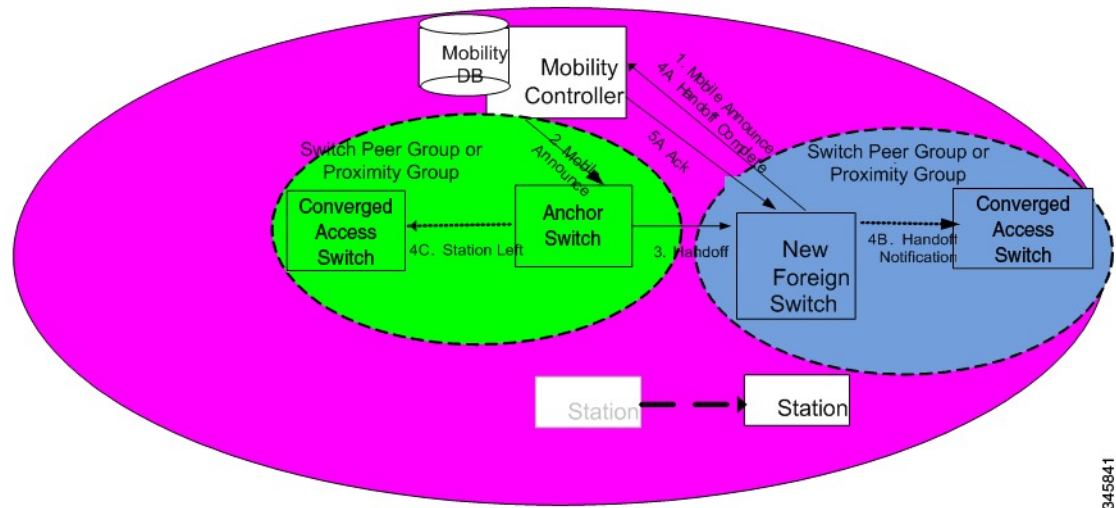
## Inter Switch Peer Group Handoff

The Intra SPG roams do not cover all possible scenarios and there can be cases where it is possible for mobility events to occur between two MAs that are not in the same SPG.

When a MA does not have any information about a station's current point of attachment, because of the Handoff Notification message getting lost in the network, or because of the the station roaming to an MA that is not in the new SPG, the MA consults the MC. The MC provides information about the clients point of presence within the mobility sub-domain. This eliminates the need to consult all other MCs within the mobility sub-domain.



Figure 73: Inter Switch Peer Group Handoff



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The image above illustrates an example of a mobility event that occurs across MAs that are not in the same SPG, but within the same mobility sub-domain.



**Note** The MA color matches the circle representing its SPG.

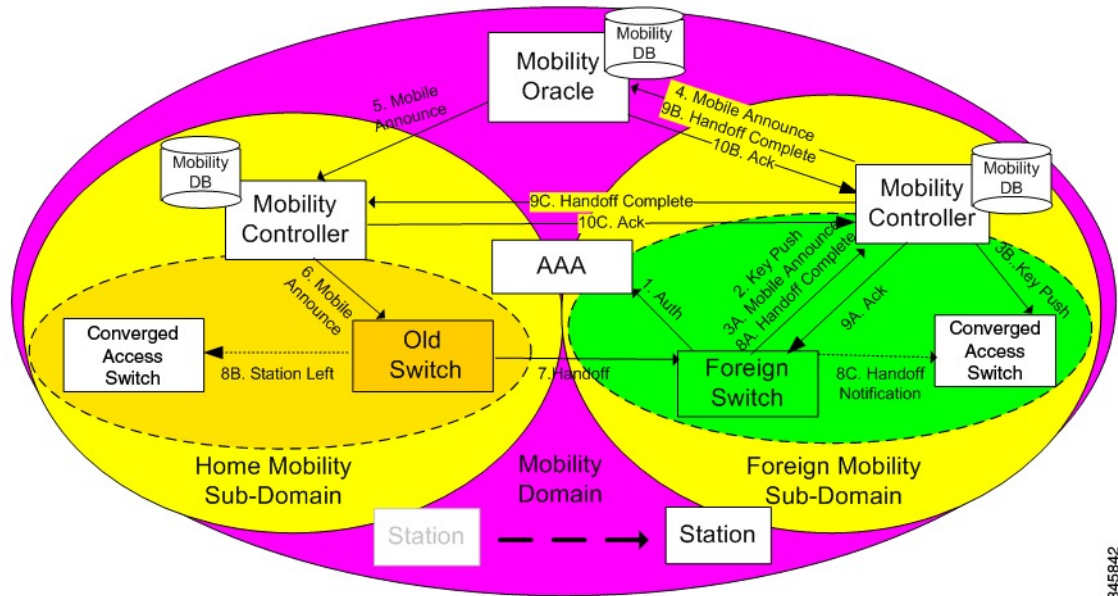
1. The new MA will have the PMK for the station, which was forwarded to each MA in the mobility sub-domain upon client initial authentication.
2. Since the MA had not been previously notified of the station's presence on a neighboring MA inside a different SPG transmits the mobile announce to the sub-domain's MC.
3. (Refer to step 2 in the illustration) On receiving the mobile announce message, the MC performs a lookup in its database, and forwards the request to the MA that was previously providing service to the station. This information is known to the MC through a previously received Handoff Complete message sent in a reliable fashion from the old MA.
4. (Refer to step 3 in the illustration) The old MA, shown in green above, transmits a Handoff message directly to the new MA.
5. The old MA needs to notify other MAs within its SPG of the fact that the station has left the group using a Station Left message. This ensures that if the station were to come back to one of the MA, they would be aware of the fact that the station is no longer being serviced by the old MA.
6. Once the handoff is complete, the new MA transmits the Handoff Complete message in a reliable fashion to the MC.
7. The new MA then transmits the Handoff Notification to the other MAs within its SPG.

## Inter Sub Domain Handoff

A sub-domain is an ensemble formed by a mobility controller and the mobility agents it directly manages. An inter sub-domain mobility event implies communication between two mobility controllers. These 2 mobility controllers can be configured with the same mobility group value and recognize each other. They will appear in each other's mobility list, or they can be configured with different mobility group values, and still recognize each other.

When the roaming event occurs across sub-domains between MCs in the same mobility group, the 802.11r key domain advertised by the new APs are the same. Additionally, the client PMK is also transmitted to all MCs upon the client's initial authentication. The new MC does not need to force the client to reauthenticate, and the new MC also knows which previous MC was managing the wireless client mobility.

Figure 74: Inter Sub Domain Handoff



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The following steps are involved in the inter sub domain handoff, when mobility controllers belong to the same mobility group:

1. When a clients PMK was sent by the initial MA to all the MCs in the mobility group, the new MA already had already received the client PMK from its MC, and re-authentication is not required.
2. The new MA was not notified previously of the station's presence on a neighboring MA inside a different SPG it transmits the mobile announce to the sub-domain's MC.
3. On receiving the mobile announce message, the MC forwards the mobile announce to the MO, which performs a lookup in its database, and forwards the request to the MC that was previously providing service to the station.
4. The previous MC, in turn, forwards the request to the MA that was previously providing service to the station.
5. The old MA, shown in yellow color above, transmits a Handoff message directly to the new MA.
6. The old MA must notify the other MAs within its SPG of the fact that the station has left the SPG using a Station Left message. This ensures that if the station comes back to one of the MA , the MA is aware of the fact that the station is no longer serviced by the old MA.
7. Once the handoff is complete, the new MA transmits the Handoff Complete message in a reliable fashion to the new Mobility Controller.
8. The new MA then transmits the Handoff Notification to all other MAs.
9. The new MC then transmits the Handoff Complete to the old MC.

## Inter Mobility Group Handoff

A mobility group is formed by MCs sharing the same mobility group name, and knowing each other.

Since the roaming event occurs across mobility groups, the 802.11r key domain advertised by the new APs differ. This forces the client to re-authenticate. They are propagated only within a mobility group, and roaming across mobility groups requires the stations to re-authenticate when they cross mobility group boundaries. When the authentication is complete, the PMK that is generated is pushed to the MAs and MCs within the same mobility group. The stations cache the PMK from the previous sub-domain because each PMK is associated to a given sub-domain (802.11y key domain). This ensures that you do not have to re-authenticate when the PMK roams back to the previous sub-domain within the pmk cache timeout interval. The remaining procedure follows the inter-sub-domain handoff steps, except that these steps relate to inter mobility group roaming.





# CHAPTER 65

## Configuring Mobility

- [Configuring Mobility Controller, on page 951](#)
- [Configuring Mobility Agent, on page 957](#)
- [Managing Mobility Agents with Mobility Controller, on page 959](#)

### Configuring Mobility Controller

#### Configuring Converged Access Controllers

##### Creating Peer Groups, Peer Group Member, and Bridge Domain ID (CLI)

###### Before you begin

- On the mobility agent, you can only configure the IP address of the mobility controller.
- On the mobility controller, you can define the peer group and the IP address of each peer group member.

###### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>wireless mobility controller</b> <b>Example:</b> Device(config)# <b>wireless mobility controller</b>	Enables the mobility controller functionality on the device. This command is applicable only to the switch. The controller is by default a mobility controller.
<b>Step 2</b>	<b>wireless mobility controller peer-group SPG1</b> <b>Example:</b> Device(config)# <b>wireless mobility controller peer-group SPG1</b>	Creates a peer group named SPG1.

	Command or Action	Purpose
<b>Step 3</b>	<b>wireless mobility controller peer-group</b> <i>SPG1</i> <b>member ip</b> <i>member-ip-addr</i> <b>public-ip</b> <i>public-ip-addr</i>  <b>Example:</b> Device(config)# <b>wireless mobility controller peer-group</b> <b>SPG1 member ip</b> 10.10.20.2 <b>public-ip</b> 10.10.20.2	Adds a mobility agent to the peer group.  <b>Note</b> The 10.10.20.2 is the mobility agent's direct IP address. When NAT is used, use the optional public IP address to enter the mobility agent's NATed address. When NAT is not used, the public IP address is not used and the device displays the mobility agent's direct IP address.
<b>Step 4</b>	<b>wireless mobility controller peer-group</b> <i>SPG1</i> <b>member ip</b> <i>member-ip-addr</i> <b>public-ip</b> <i>public-ip-addr</i>  <b>Example:</b> Device(config)# <b>wireless mobility controller peer-group</b> <b>SPG1 member ip</b> 10.10.20.6 <b>public-ip</b> 10.10.20.6	Adds another member to the peer group SPG1.
<b>Step 5</b>	<b>wireless mobility controller peer-group</b> <i>SPG2</i>  <b>Example:</b> Device(config)# <b>wireless mobility controller peer-group</b> <b>SPG2</b>	Creates another peer group SPG2.
<b>Step 6</b>	<b>wireless mobility controller peer-group</b> <i>SPG2</i> <b>member ip</b> <i>member-ip-addr</i> <b>public-ip</b> <i>public-ip-addr</i>  <b>Example:</b> Device(config)# <b>wireless mobility controller peer-group</b> <b>SPG2 member ip</b> 10.10.10.20 <b>public-ip</b> 10.10.10.20	Adds a member to peer group SPG2.
<b>Step 7</b>	<b>wireless mobility controller peer-group</b> <i>SPG1</i> <b>bridge-domain-id</b> <i>id</i>  <b>Example:</b> Device(config)# <b>wireless mobility controller peer-group</b> <b>SPG1 bridge-domain-id</b> 54	(Optional) Adds a bridge domain to SPG1 used for defining the subnet-VLAN mapping with other SPGs.

### Example

This example shows how to create peer group and add members to it:

```
Device(config)# wireless mobility controller
Device(config)# wireless mobility controller peer-group SPG1
Device(config)# wireless mobility controller peer-group SPG1
Device(config)# wireless mobility controller peer-group SPG1 member ip 10.10.20.2 public-ip
```

```

10.10.20.2
Device(config)# wireless mobility controller peer-group SPG1 member ip 10.10.20.6 public-ip
10.10.20.6
Device(config)# wireless mobility controller peer-group SPG2
Device(config)# wireless mobility controller peer-group SPG2 member ip 10.10.10.20 public-ip
10.10.10.20
Device(config)# wireless mobility controller peer-group SPG1 bridge-domain-id 54

```

## Configuring Local Mobility Group (CLI)

Configuration for wireless mobility groups and mobility group members where the mobility group is a group of MCs.

### Before you begin

MCs can belong only to one mobility group, and can know MCs in several mobility groups.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>wireless mobility group name</b> <i>group-name</i> <b>Example:</b> Device(config)# wireless mobility group name Mygroup	Creates a mobility group named <b>Mygroup</b> .
<b>Step 2</b>	<b>wireless mobility group member ip</b> <i>member-ip-addr</i> <b>public-ip</b> <i>public-ip-addr</i> <b>Example:</b> Device(config)# wireless mobility group member ip 10.10.34.10 public-ip 10.10.34.28	Adds a mobility controller to the <b>Mygroup</b> mobility group.  <b>Note</b> When NAT is used, use the optional public IP address to enter the NATED IP address of the mobility controller.
<b>Step 3</b>	<b>wireless mobility group keepalive interval</b> <i>time-in-seconds</i> <b>Example:</b> Device(config)# wireless mobility group keepalive interval 5	Configures the interval between two keepalives sent to a mobility member.
<b>Step 4</b>	<b>wireless mobility group keepalive count</b> <i>count</i> <b>Example:</b> Device(config)# wireless mobility group keepalive count 3	Configures the keep alive retries before a member status is termed DOWN.

### Example

```

Device(config)# wireless mobility group name Mygroup
Device(config)# wireless mobility group member ip 10.10.34.10 public-ip 10.10.34.28
Device(config)# wireless mobility group keepalive interval 5
Device(config)# wireless mobility group keepalive count 3

```

## Adding a Peer Mobility Group (CLI)

### Before you begin

MCs belong to only one group, and can know MCs in several groups.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>wireless mobility group member ip</b> <i>member-ip-addr public-ip public-ip-addr</i> <b>group group-name</b>  <b>Example:</b> Device(config)# <b>wireless mobility group</b> <b>member ip 10.10.10.24 public-ip</b> <b>10.10.10.25 group Group2</b>	Adds the member as a peer MC in a different group than the <b>Mygroup</b> .

## Configuring Optional Parameters for Roaming Behavior

Use this configuration to disable the sticky anchor. This command can also be used, if required, between all MA's and MC's where roaming is expected for the target SSID.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>wlan open21</b>  <b>Example:</b>  Device(config)# wlan open20	Configures a WLAN.
<b>Step 2</b>	<b>no mobility anchor sticky</b>  <b>Example:</b>  Device(config-wlan)# no mobility anchor sticky	Disables the default sticky mobility anchor.

### Example

```
Device(config)# wlan open20
Device(config-wlan)# no mobility anchor sticky
```

## Pointing the Mobility Controller to a Mobility Oracle (CLI)

### Before you begin

You can configure a mobility oracle on a known mobility controller.



**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>wireless mobility group member ip</b> <i>member-ip-addr group group-name</i>  <b>Example:</b> Device(config)# <b>wireless mobility group</b> <b>member ip 10.10.10.10 group Group3</b>	Creates and adds a MC to a mobility group.
<b>Step 2</b>	<b>wireless mobility oracle ip</b> <i>oracle-ip-addr</i>  <b>Example:</b> Device(config)# <b>wireless mobility oracle</b> <b>ip 10.10.10.10</b>	Configures the mobility controller as mobility oracle.

**Example**

```
Device(config)# wireless mobility group member ip 10.10.10.10 group Group3
Device(config)# wireless mobility oracle ip 10.10.10.10
```

**Configuring Guest Controller**

A guest controller is used when the client traffic is tunneled to a guest anchor controller in the demilitarized zone (DMZ). The guest client goes through a web authentication process. The web authentication process is optional, and the guest is allowed to pass traffic without authentication too.

Enable the WLAN on the mobility agent on which the guest client connects with the mobility anchor address of the guest controller.

On the guest controller WLAN, which can be Cisco 5500 Series WLC, Cisco WiSM2, or Cisco 5700 Series WLC, configure the IP address of the mobility anchor as its own IP address. This allows the traffic to be tunneled to the guest controller from the mobility agent.



**Note** With Cisco 5700 Series WLC as the guest anchor controller and Cisco 5500 Series WLC or Cisco WiSM2 as export foreign controller, the guest user role per user is not supported on the Cisco 5700 Series WLC.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>wlan</b> <i>wlan-id</i>  <b>Example:</b> Device(config)# <b>wlan Mywlan1</b>	Creates a WLAN for the client.

	Command or Action	Purpose
<b>Step 2</b>	<b>mobility anchor</b> <i>guest-anchor-ip-addr</i> <b>Example:</b> Device(config-wlan)# <b>mobility anchor</b> 10.10.10.2	Enables the guest anchors (GA) IP address on the MA.  <b>Note</b> To enable guest anchor on the mobility controller, you need not enter the IP address. Enter the <b>mobility anchor</b> command in the WLAN configuration mode to enable GA on the mobility controller.
<b>Step 3</b>	<b>client vlan</b> <i>vlan-name</i> <b>Example:</b> Device(config-wlan)# <b>client vlan</b> gc_ga_vlan1	Assigns a VLAN to the client's WLAN.
<b>Step 4</b>	<b>security open</b> <b>Example:</b> Device(config-wlan)# <b>security open</b>	Assigns a security type to the WLAN.

### Example

```

Device(config)# wlan Mywlan1
Device(config-wlan)# mobility anchor 10.10.10.2
Device(config-wlan)# client vlan gc_ga_vlan1
Device(config-wlan)# security open
  
```

## Configuring Guest Anchor

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>wlan</b> <i>Mywlan1</i> <b>Example:</b> Device(config)# wlan Mywlan1	Creates a wlan for the client.
<b>Step 2</b>	<b>mobility anchor</b> <b>&lt;guest-anchors-own-ip-address&gt;</b> <b>Example:</b> Device(config-wlan)# mobility anchor 10.10.10.2	Enables the guest anchors IP address on the guest anchor (GA). The GA assigns its own address on itself.
<b>Step 3</b>	<b>client vlan</b> <b>&lt;vlan-name&gt;</b> <b>Example:</b> Device(config-wlan)# client vlan gc_ga_vlan1	Assigns a vlan to the clients wlan.

	Command or Action	Purpose
<b>Step 4</b>	<b>security open</b> <b>Example:</b> Device(config-wlan)# security open	Assigns a security type to the wlan.

### Example

```
Device(config)# wlan Mywlan1
Device(config-wlan)# mobility anchor 10.10.10.2
Device(config-wlan)# client vlan gc_ga_vlan1
Device(config-wlan)# security open
```

# Configuring Mobility Agent

## Configuring Mobility Agent by Pointing to Mobility Controller (CLI)

### Before you begin

- By default, the switches are configured as mobility agents.
- Your network must have at least one mobility controller and the network connectivity with the mobility controller must be operational.
- You cannot configure mobility from the mobility agent. On the mobility agent, you can configure only the IP address of the mobility controller to download the SPG configuration.
- On the mobility agent, you can either configure the mobility controller address to point to an external mobility agent, or enable the mobility controller function.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>wireless management interface vlan 21</b> <b>Example:</b> Device (config)# wireless management interface vlan 21	Enables the wireless functionality on the device and activates the mobility agent function. This ensures the APs have a place to terminate the CAPWAP tunnel.

**Example**

This example shows how to add a mobility agent into the mobility group by pointing it to a mobility controller:

```
Device(config)# wireless management interface vlan 21
```

## Configuring the Mobility Controller for the Mobility Agent (CLI)

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>wireless mobility controller</b>  <b>Example:</b> Device (config)# <b>wireless mobility controller</b> Mobility role changed to Mobility Controller. Please save config and reboot the whole stack.	Enables the mobility function on the device.  <b>Note</b> After you enter this command, save the configuration and reboot the device for the mobility controller function to take effect.
<b>Step 2</b>	<b>wireless mobility controller ip ip-addr</b>  <b>Example:</b> Device (config)# <b>wireless mobility controller ip 10.10.21.3</b>	Specifies the mobility controller to which the mobility agent relates.  <b>Note</b> If a mobility agent is configured and the mobility controller exists on a different device, configure the SPG on the mobility controller to ensure the mobility agent functions properly.

**What to do next**

After you add a mobility controller role to the mobility agent, you can configure optional parameters on the mobility agent.

## Adding a Mobility Controller Role to the Mobility Agent

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>wireless mobility controller ip 10.10.21.3</b>  <b>Example:</b>	Converts the mobility agent to a mobility controller.

	Command or Action	Purpose
	Device(config)# wireless mobility controller ip 10.10.21.3	

### Example

This example shows how to add the mobility controller role to a mobility agent:

```
Device(config)# wireless mobility controller ip 10.10.21.3
Mobility role changed to Mobility Controller.
Please save config and reboot the whole stack.
```

## Configuring Optional Parameters on a Mobility Agent (CLI)

This section shows how to configure load-balancing on a device.

- By default, the load-balancing is enabled and it cannot be disabled.
- The device supports a maximum of 2000 clients and the default threshold value is fifty percent of client max load.
- When the device reaches its threshold, it redistributes the new clients load to other mobility agents in the same SPG, if their client load is lower.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>wireless mobility load-balance threshold</b> <i>threshold-value</i>  <b>Example:</b> Device(config)# wireless mobility load-balance threshold 150	Configures the threshold that triggers load-balancing.

## Managing Mobility Agents with Mobility Controller

### Managing Mobility Agents with Mobility Controller

The Mobility Controller managing Mobility Agent feature pushes the wireless and common configurations from the Mobility Controller (MC) to the Mobility Agents (MAs). This helps you to easily configure, monitor, and troubleshoot all the MAs from the MC. An MC can support up to 16 MAs. Most of the wireless and common configurations such as AAA, ACL, and so on are generally the same across all the switches.

## Restrictions for Managing Mobility Agents with Mobility Controller

- The MC and MAs can become unsynchronized when a new MA joins the MC, and this MA is centrally managed, and when an MA is moved from one MC to another MC.
- When an MA is in centralized mode, the globally managed configuration is disabled and the rest of the configurations and monitoring are available on the Web GUI.
- This feature is not supported on Cisco Prime Infrastructure.
- When the MC detects an MA to be out of sync, the MA is forced to reload and then resync the entire configuration from the MC after coming up again.
- QoS configuration is not pushed from the MC to an MA.
- The MC pushes all the configurations to all the centrally managed MAs. It is not possible to select a subset of the configurations and then push to a particular group of MAs instead of all the MAs.
- L3 roaming is not supported because WLAN configuration is pushed from the MC.
- MAs using different software versions in the subdomain either in the same Switch Peer Group (SPG) or in a different SPG are not supported.
- If Catalyst 3850 and 3650 Switch act as an MC in a mobility subdomain, the MC and MAs only run Polaris release 16.2 and Polaris release 16.1.1.
- Since only Catalyst 3850 Switches are allowed in the mobility subdomain there cannot be a 5760 added to a MC when Polaris version acts as MA.
- In 16.2 Denali release, the Cisco 3850 controller supports a maximum of 50 APs in MA or MC. In MC-MA scenario, a maximum of 100 APs are supported, which includes APs of both MA and MC.

## Feature History

Release	Remarks
Cisco IOS XE Denali 16.2.1	The feature was introduced on the Cisco Catalyst 3850 and Cisco Catalyst 3650 Series Switches.

For a complete list of commands that are synchronized between the MC and the MA, see *MC Managing MA - List of Commands Synchronized Between MC and MA* at:

<http://www.cisco.com/c/en/us/td/docs/wireless/controller/mc-ma/mc-ma-sync.html>.

## Information About Managing Mobility Agents with Mobility Controller

A Mobility Controller (MC) can have both centrally managed and noncentrally managed Mobility Agents (MAs) at the same time. A centrally managed MA receives a set of configurations that are configured on the MC. A noncentrally managed MA does not receive any configuration from the MC. While an MA is being centrally managed, you can not modify any of the configurations that are pushed from the MC to an MA.

The MC pushes all the relevant configurations over the existing Control and Provisioning of Wireless Access Point (CAPWAP) tunnel to all the centrally managed MAs. The MC also pushes incremental configurations, if any, to the MAs.

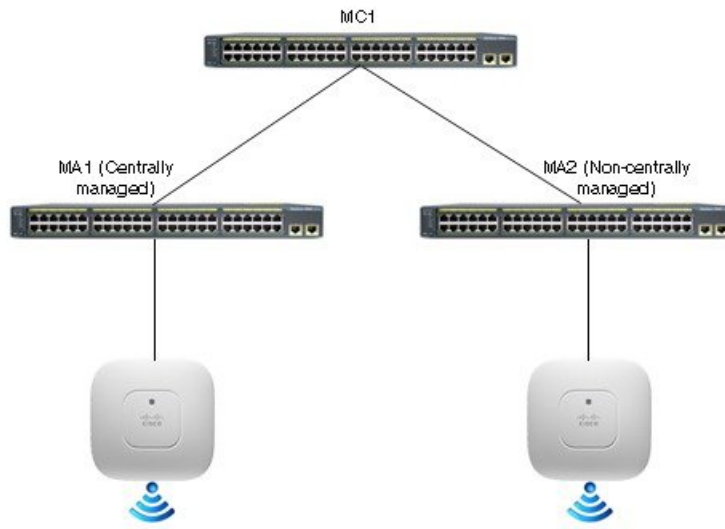


**Note** Before using this feature, you must have the Day 0 configuration that is required to bring up the CAPWAP tunnel between the MC and an MA.

The following configurations are sent to the MAs:

- Common configuration—This is the configuration, that is shared between wired and wireless configurations such as the security configuration, for example, authentication, authorization, and accounting (AAA).
- Wireless configurations—All wireless configurations.

**Figure 75: MC Managing MAs**



## Distributed Mode and Centralized Mode

Distributed mode refers to configurations that are required to be performed explicitly on all the MAs.

Centralized mode refers to configurations where wireless and common configurations are pushed from the MC to the MAs. The following table lists the differences between the Distributed mode and the Centralized mode.

**Table: Differences Between Distributed Mode and Centralized Mode**

Distributed Mode	Centralized Mode
Configurations on the MC	Configurations on the MC

Distributed Mode	Centralized Mode
<ul style="list-style-type: none"> <li>• MA to MC Mobility Peering Configuration</li> <li>• Wireless LAN</li> <li>• Wireless QoS Policies</li> <li>• Wireless Security ACL</li> <li>• AAA Global Configurations</li> <li>• Location</li> <li>• Cisco CleanAir, Radio Resource Management (RRM), Client Link</li> <li>• Global and Per-AP Configuration</li> </ul>	<ul style="list-style-type: none"> <li>• MA to MC Mobility Peering Configuration</li> <li>• Wireless LAN</li> <li>• Wireless Security ACL</li> <li>• AAA Global Configurations</li> <li>• Location</li> <li>• Cisco CleanAir, RRM, Client Link</li> <li>• Global and Per-AP Configuration</li> </ul>
Configurations on an MA	Configurations on an MA
<ul style="list-style-type: none"> <li>• MA to MC Mobility Peering Configuration</li> <li>• Wireless LAN</li> <li>• Wireless QoS Policies</li> <li>• Wireless Security ACL</li> <li>• AAA Global Configurations</li> <li>• Location</li> <li>• Cisco CleanAir, RRM, Client Link</li> <li>• Global and Per-AP Configuration</li> </ul>	<ul style="list-style-type: none"> <li>• MA to MC Mobility Peering Configuration</li> <li>• Wireless QoS Policies</li> </ul>

## Restrictions for Managing Mobility Agents with Mobility Controller

- The MC and MAs can become unsynchronized when a new MA joins the MC, and this MA is centrally managed, and when an MA is moved from one MC to another MC.
- When an MA is in centralized mode, the globally managed configuration is disabled and the rest of the configurations and monitoring are available on the Web GUI.
- This feature is not supported on Cisco Prime Infrastructure.
- When the MC detects an MA to be out of sync, the MA is forced to reload and then resync the entire configuration from the MC after coming up again.
- QoS configuration is not pushed from the MC to an MA.
- The MC pushes all the configurations to all the centrally managed MAs. It is not possible to select a subset of the configurations and then push to a particular group of MAs instead of all the MAs.
- L3 roaming is not supported because WLAN configuration is pushed from the MC.



- MAs using different software versions in the subdomain either in the same Switch Peer Group (SPG) or in a different SPG are not supported.
- If Catalyst 3850 and 3650 Switch act as an MC in a mobility subdomain, the MC and MAs only run Polaris release 16.2 and Polaris release 16.1.1.
- Since only Catalyst 3850 Switches are allowed in the mobility subdomain there cannot be a 5760 added to a MC when Polaris version acts as MA.
- In 16.2 Denali release, the Cisco 3850 controller supports a maximum of 50 APs in MA or MC. In MC-MA scenario, a maximum of 100 APs are supported, which includes APs of both MA and MC.

## Configuring MC Managing MA (CLI)

The following procedure shows how to configure Managing Mobility Agents with Mobility Controller:

### Procedure

#### Step 1 Configuring MC:

- a) Configure a wireless management interface by entering this command:

```
Device(config)# wireless management interface vlan vlan-id
```

- b) Configure a switch peer group by entering this command:

```
Device(config)# wireless mobility controller peer-group spg-name
```

- c) Add an MA to the SPG and configure it to be centrally managed by entering this command: (Use only centralized option)

```
Device(config)# wireless mobility controller peer-group spg-name member ip ip-addr mode centralized
```

#### Step 2 Configuring MA:

- a) Specify the IP address of the MC by entering this command:

```
Device(config)# wireless mobility controller ip mc-ip-addr
```

- b) Configure the wireless management interface by entering this command:

```
Device(config)# wireless management interface vlan vlan-id
```

#### Step 3 Configuring Centralized Mode:

- a) From the MC, you can see the status of the MA by entering this command:

```
Device(config)# show wireless mobility summary
```

```
Mobility Controller Summary:
```

```
Mobility Role                : Mobility Controller
Mobility Protocol Port       : 16666
Mobility Group Name          : default
Mobility Oracle IP Address   : 0.0.0.0
DTLS Mode                    : Enabled
Mobility Domain ID for 802.11r : 0xac34
Mobility Keepalive Interval  : 10
Mobility Keepalive Count     : 3
```

```
Mobility Control Message DSCP Value      : 48
Mobility Domain Member Count            : 1
```

```
IP          Public IP      Link   Status   Centralized(Cfgd : Running)
-----
1.1.1.1     1.1.1.1     UP    : UP     Enabled   Enabled
3.3.3.1     3.3.3.1     DOWN : DOWN   Enabled   Enabled
```

The following table shows the details of the Centralized Mode (both Configured and Running) in relation to the example above.

**Table 66: Centralized Mode (Configured and Running)**

SI. No.	Centralized Mode Configuration	Centralized Mode Running	What it Means
1.	Disabled	Disabled	The MA is not configured as centrally managed on the MC.
2.	Enabled	Disabled	The MA is configured as centrally managed on the MC, but the tunnel to the MA is still down, or the MA is yet to acknowledge the message from the MC (the message in which the MC informs the MA that it is centrally managed).
3.	Enabled	Enabled	The MA is configured as centrally managed on the MC and the MA is running in Centrally Managed mode.
4.	Disabled	Enabled	Not applicable.

- b) You can see all the MAs that have been configured on the MC irrespective of the SPG and irrespective of whether they are centrally managed or not, by entering this command:

```
Device(config)# show cmm member-table

CMM Member Table
-----
Total No Of Members = 1
System Rev No on MC = 16

entry 0
-----
entry_status          = In use
ip_addr               = 10.5.84.155
SPG Name              = SPG1
Centrally Managed     = True
Applied Cfg rev on MA = 16
Last rcvd cfg rev on MA = 16
Tunnel State          = Up
```

```
Status = CMM_MEMBER_STATUS_IN_SYNC
Last sent cfg rev to MA = 16
Last sent cfg timestamp = 1427826323 sec 936009397 nsec
-----
```

```
Members: No. of MAs configured on the MC
System Rev No on MC: What version number the MC is at
```

```
Entry
```

- c) To see the configurations that were executed on an MC and buffered in the CMM agent, enter this command:

```
Device(config)# show cmm config

Current version number: 17
To sync and save configuration to Mobility Agents execute: "write memory"

Config commands present in the buffer:
access-list 1 permit any
wlan MCMA_Demo 4 MCMA_Demo
client vlan 22
no security wpa
no security wpa akm dot1x
no security wpa wpa2
no security wpa wpa2 ciphers aes
no shutdown
```

**Note** The configuration from the MC is synchronized with MAs only after the **write memory** command is run on the MC.

- Step 4** To execute the commands on an MA remotely from the MC, use this command. For example, you can enter this command on the MC to see if the client has reached the uptime.

```
Device(config)# remote command 1.1.1.1 show wcdb da all
Total Number of Wireless Clients = 1
Clients Waiting to Join = 0
Local Clients = 0
Anchor Clients = 1
Foreign Clients = 0
MTE Clients = 0
Mac Address VlanId IP Address Src If Auth Mob
-----
ec55.f9c6.35c3 22 53.1.1.2 0x00D19B00000001C5 RUN ANCHOR
```

- Step 5** To log in remotely to an MA from the MC, use this command:

```
DeviceControllerDevice(config)# remote login 1.1.1.1

Trying Switch ...
Entering CONSOLE for Switch
Type "^C^C^C" to end this session

User Access Verification

Password:
MA1>en
Password:
```

```
MA1#
```

---

## Configuration of WLAN on the MC

This following procedure shows how to create a WLAN on the MC and synchronize the WLAN configuration with centrally managed MCs.

### Procedure

---

**Step 1** On the MC, create a WLAN named MCMA\_Demo by entering this command:

```
Device(config)# wlan MCMA_Demo 1 MCMA_Demo
Device(config-wlan)# exit
Device(config)# exit
```

**Step 2** Enter this command to check the configuration:

```
Device(config)# show cmm config

Current version number: 3
To sync and save configuration to Mobility Agents execute: "write memory"

Config commands present in the buffer:
wlan MCMA_Demo 1 MCMA_Demo
exit
```

**Step 3** Enter this command to check the number of MAs that are configured to be centrally managed:

```
Device(config)# show cmm member-table

CMM Member Table
-----
Total No Of Members = 1
System Rev No on MC = 2

entry 0
-----
entry_status          = In use
ip_addr               = 10.5.84.12
SPG Name              = SPG1
Centrally Managed     = True
Applied Cfg rev on MA = 2
Last rcvd cfg rev on MA = 2
Tunnel State          = Up
Status                = CMM_MEMBER_STATUS_IN_SYNC
Last sent cfg rev to MA = 2
Last sent cfg timestamp = 1432843797 sec 57656031 nsec
-----
```

**Step 4** See the WLAN details by entering this command:

```
Device(config)# show wlan summary

Number of WLANs: 1
```

```

WLAN  Profile Name   SSID           VLAN Status
-----
1      MCMA_Demo         MCMA_Demo      1      DOWN

```

**Step 5** Save the configuration by entering this command:

```

Device(config)# write memory

Building configuration...
Compressed configuration from 7612 bytes to 3409 bytes[OK]

```

**Step 6** Check the synchronization status on an MA by entering this command:

```

Device(config)# show cmm member-table

CMM Member Table
-----
Total No Of Members = 1
System Rev No on MC = 3

entry 0
-----
entry_status          = In use
ip_addr               = 10.5.84.12
SPG Name              = SPG1
Centrally Managed     = True
Applied Cfg rev on MA = 2
Last rcvd cfg rev on MA = 2
Tunnel State          = Up
Status                = CMM_MEMBER_STATUS_STALE
Last sent cfg rev to MA = 3
Last sent cfg timestamp = 1432847325 sec 107200589 nsec
-----

```

**Step 7** On the MA, enter the following command to verify if the WLAN that was created in the MC is now synchronized with the MA:

```

Device(config)# show wlan summary

Number of WLANs: 1

WLAN  Profile Name   SSID           VLAN Status
-----
1      MCMA_Demo         MCMA_Demo      1      DOWN

```

**Example:**

Example logs showing how multiple configurations are synchronized

---

**The following example shows output of cmm configuration:**

**The following example shows output of to view the cmm member-table:**

**The following example shows output of to view WLAN Summary:**

**The following example shows output of to write memory:**

**The following example shows output of WLAN summary:**

**The following example shows output of cmm member-table:**

**The following example shows output of cmm member-table:**

**The following example shows output of cmm member-table:**

**The following example shows output of configuration MA:**

**The following example shows output of WLAN summary:**

**The following example shows output of configuring cmm:**

**The following example shows output of view and run the WLAN:**

**The following example shows output of view and run the WLAN open:**

```
MC#show cmm config
Current version number: 4
To sync and save configuration to Mobility Agents execute: "write memory"

Config commands present in the buffer:
wlan open 2 open
assisted-roaming dual-list
assisted-roaming neighbor-list
broadcast-ssid
ccx aironet-iesupport
channel-scan defer-priority 4
client association limit ap 0
client association limit radio 0
client vlan default
exclusionlist
exclusionlist timeout 60
ip access-group web none
mac-filtering test
mobility anchor sticky
radio all
security wpa
security wpa akm dot1x
security wpa wpa2
security wpa wpa2 ciphers aes
security dot1x authentication-list test
```

```

security dot1x encryption 104
security ft over-the-ds
security ft reassociation-timeout 20
security static-wep-key authentication open
security tkip hold-down 60
security web-auth authentication-list test2
security web-auth parameter-map test3
service-policy client input un
service-policy client output un
service-policy input unk
service-policy output unk
session-timeout 1800
no shutdown
exit

```

To view cmm member-table:

```

MC#show cmm member-table
CMM Member Table

```

```

-----

```

```

Total No Of Members = 1
System Rev No on MC = 3

```

```

entry 0

```

```

-----

```

```

entry_status           = In use
ip_addr                = 10.5.84.12
SPG Name               = SPG1
Centrally Managed     = True
Applied Cfg rev on MA = 3
Last rcvd cfg rev on MA = 3
Tunnel State          = Up
Status                 = CMM_MEMBER_STATUS_IN_SYNC
Last sent cfg rev to MA = 3
Last sent cfg timestamp = 1433441315 sec 669464681 nsec
-----

```

To view WLAN summary:

```

MC#show wlan summary

```

```

Number of WLANs: 2

```

WLAN Profile Name	SSID	VLAN	Status
1 test	test	1	DOWN
2 open	open	1	UP

To write memory:

```

MC#write mem

```

```

Building configuration...

```

```

Compressed configuration from 7972 bytes to 3619 bytes[OK]

```

```

MC#show wlan summary

```

```

Number of WLANs: 2

```

WLAN Profile Name	SSID	VLAN	Status
-------------------	------	------	--------

```
-----
1   test                               test                               1   DOWN
2   open                               open                               1   UP
```

To view cmmm config:

MC#show cmm config

Current version number: 4

To sync and save configuration to Mobility Agents execute: "write memory"

Config commands present in the buffer:

MC#show cmm member-table

CMM Member Table

-----

Total No Of Members = 1

System Rev No on MC = 4

entry 0

-----

```
entry_status      = In use
ip_addr           = 10.5.84.12
SPG Name          = SPG1
Centrally Managed = True
Applied Cfg rev on MA = 3
Last rcvd cfg rev on MA = 3
Tunnel State      = Up
Status            = CMM_MEMBER_STATUS_STALE
Last sent cfg rev to MA = 4
Last sent cfg timestamp = 1433488804 sec 349065646 nsec
-----
```

MC#show cmm member-table

CMM Member Table

-----

Total No Of Members = 1

System Rev No on MC = 4

entry 0

-----

```
entry_status      = In use
ip_addr           = 10.5.84.12
SPG Name          = SPG1
Centrally Managed = True
Applied Cfg rev on MA = 3
Last rcvd cfg rev on MA = 3
Tunnel State      = Up
Status            = CMM_MEMBER_STATUS_STALE
Last sent cfg rev to MA = 4
Last sent cfg timestamp = 1433488812 sec 349323943 nsec
-----
```

MC#show cmm member-table

CMM Member Table

-----

Total No Of Members = 1

System Rev No on MC = 4

entry 0

-----



```

entry_status          = In use
ip_addr               = 10.5.84.12
SPG Name              = SPG1
Centrally Managed     = True
Applied Cfg rev on MA = 4
Last rcvd cfg rev on MA = 4
Tunnel State         = Up
Status                = CMM_MEMBER_STATUS_IN_SYNC
Last sent cfg rev to MA = 4
Last sent cfg timestamp = 1433488820 sec 349544632 nsec
-----
MC#

```

```

To view the cmm configuration
MA21#show cmm config
Current version number: 3
Centrally Managed: True

```

```
MA21#show wlan summary
```

```
Number of WLANs: 1
```

WLAN Profile Name	SSID	VLAN	Status
1 test	test	1	DOWN

```
MA21#
Building configuration...
```

```

*Jun  5 07:21:18.295: %SYS-5-CONFIG_I: Configured from console by vty1
*Jun  5 07:21:18.314: %CMM-6-CONFIG_SYNC_SAVE_MSG: Saving config rev#4 received
from Mobility Controller.Compressed configuration from 13033 bytes to 4340 bytes[OK]

```

```

MA21#show cmm config
Current version number: 4
Centrally Managed: True
MA21#show wlan summary

```

```
Number of WLANs: 2
```

WLAN Profile Name	SSID	VLAN	Status
1 test	test	1	DOWN
2 open	open	1	UP

```

MA21#show run wlan
wlan test 1 test
  shutdown
wlan open 2 open
  assisted-roaming dual-list
  assisted-roaming neighbor-list
  ip access-group web none
  mac-filtering test
  security dot1x authentication-list test
  security web-auth authentication-list test2
  security web-auth parameter-map test3
  service-policy client input un

```

```
service-policy client output un
service-policy input unk
service-policy output unk
no shutdown
MA21#
```

```
To view and run the WLAN open
MA21#show run wlan open
wlan open 2 open
  assisted-roaming dual-list
  assisted-roaming neighbor-list
  ip access-group web none
  mac-filtering test
  security dot1x authentication-list test
  security web-auth authentication-list test2
  security web-auth parameter-map test3
  service-policy client input un
  service-policy client output un
  service-policy input unk
  service-policy output unk
  no shutdown
MA21#
MA21#
```



## PART **XI**

# Multiprotocol Label Switching

- [Configuring Multiprotocol Label Switching \(MPLS\), on page 975](#)
- [Configuring Multicast Virtual Private Network, on page 983](#)





## CHAPTER 66

# Configuring Multiprotocol Label Switching (MPLS)

---

- [Multiprotocol Label Switching, on page 975](#)
- [Restrictions for Multiprotocol Label Switching, on page 975](#)
- [Information about Multiprotocol Label Switching, on page 975](#)
- [How to Configure Multiprotocol Label Switching, on page 977](#)
- [Verifying Multiprotocol Label Switching Configuration, on page 979](#)

## Multiprotocol Label Switching

This module describes Multiprotocol Label Switching and how to configure it on Cisco switches.

## Restrictions for Multiprotocol Label Switching

- Multiprotocol Label Switching (MPLS) fragmentation is not supported.
- MPLS maximum transmission unit (MTU) is not supported.

## Information about Multiprotocol Label Switching

Multiprotocol label switching (MPLS) combines the performance and capabilities of Layer 2 (data link layer) switching with the proven scalability of Layer 3 (network layer) routing. MPLS enables you to meet the challenges of explosive growth in network utilization while providing the opportunity to differentiate services without sacrificing the existing network infrastructure. The MPLS architecture is flexible and can be employed in any combination of Layer 2 technologies. MPLS support is offered for all Layer 3 protocols, and scaling is possible well beyond that typically offered in today's networks.

## Functional Description of Multiprotocol Label Switching

Label switching is a high-performance packet forwarding technology that integrates the performance and traffic management capabilities of data link layer (Layer 2) switching with the scalability, flexibility, and performance of network layer (Layer 3) routing.

## Label Switching Functions

In conventional Layer 3 forwarding mechanisms, as a packet traverses the network, each switch extracts all the information relevant to forwarding the packet from the Layer 3 header. This information is then used as an index for a routing table lookup to determine the next hop for the packet.

In the most common case, the only relevant field in the header is the destination address field, but in some cases, other header fields might also be relevant. As a result, the header analysis must be done independently at each switch through which the packet passes. In addition, a complicated table lookup must also be done at each switch.

In label switching, the analysis of the Layer 3 header is done only once. The Layer 3 header is then mapped into a fixed length, unstructured value called a *label*.

Many different headers can map to the same label, as long as those headers always result in the same choice of next hop. In effect, a label represents a *forwarding equivalence class*--that is, a set of packets which, however different they may be, are indistinguishable by the forwarding function.

The initial choice of a label need not be based exclusively on the contents of the Layer 3 packet header; for example, forwarding decisions at subsequent hops can also be based on routing policy.

Once a label is assigned, a short label header is added at the front of the Layer 3 packet. This header is carried across the network as part of the packet. At subsequent hops through each MPLS switch in the network, labels are swapped and forwarding decisions are made by means of MPLS forwarding table lookup for the label carried in the packet header. Hence, the packet header does not need to be reevaluated during packet transit through the network. Because the label is of fixed length and unstructured, the MPLS forwarding table lookup process is both straightforward and fast.

## Distribution of Label Bindings

Each label switching router (LSR) in the network makes an independent, local decision as to which label value to use to represent a forwarding equivalence class. This association is known as a label binding. Each LSR informs its neighbors of the label bindings it has made. This awareness of label bindings by neighboring switches is facilitated by the following protocols:

- Label Distribution Protocol (LDP)--enables peer LSRs in an MPLS network to exchange label binding information for supporting hop-by-hop forwarding in an MPLS network
- Border Gateway Protocol (BGP)--Used to support MPLS virtual private networks (VPNs)

When a labeled packet is being sent from LSR A to the neighboring LSR B, the label value carried by the IP packet is the label value that LSR B assigned to represent the forwarding equivalence class of the packet. Thus, the label value changes as the IP packet traverses the network.

For more information about LDP configuration, see the see MPLS: LDP Configuration Guide at [http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/mppls/config\\_library/xe-3s/mp-xe-3s-library.html](http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/mppls/config_library/xe-3s/mp-xe-3s-library.html)



---

**Note**

As the scale of label entries is limited in, especially with ECMP, it is recommended to enable LDP label filtering. LDP labels shall be allocated only for well known prefixes like loopback interfaces of routers and any prefix that needs to be reachable in the global routing table.

---

## MPLS Layer 3 VPN

A Multiprotocol Label Switching (MPLS) Virtual Private Network (VPN) consists of a set of sites that are interconnected by means of an MPLS provider core network. At each customer site, one or more customer edge (CE) routers attach to one or more provider edge (PE) routers.

Before configuring MPLS Layer 3 VPNs, you should have MPLS, Label Distribution Protocol (LDP), and Cisco Express Forwarding (CEF) installed in your network. All routers in the core, including the PE routers, must be able to support CEF and MPLS forwarding.

## Classifying and Marking MPLS QoS EXP

The QoS EXP Matching feature allows you to classify and mark network traffic by modifying the Multiprotocol Label Switching (MPLS) experimental bits (EXP) field in IP packets.

The QoS EXP Matching feature allows you to organize network traffic by setting values for the MPLS EXP field in MPLS packets. By choosing different values for the MPLS EXP field, you can mark packets so that packets have the priority that they require during periods of congestion. Setting the MPLS EXP value allows you to:

- **Classify traffic:** The classification process selects the traffic to be marked. Classification accomplishes this by partitioning traffic into multiple priority levels, or classes of service. Traffic classification is the primary component of class-based QoS provisioning.
- **Police and mark traffic:** Policing causes traffic that exceeds the configured rate to be discarded or marked to a different drop level. Marking traffic is a way to identify packet flows to differentiate them. Packet marking allows you to partition your network into multiple priority levels or classes of service.

### Restrictions

Following is the list of restrictions for classifying and marking MPLS QoS EXP:

- Only Uniform mode and Pipe mode are supported; Short-pipe mode is not supported.
- Support range of QoS-group values range between 0 and 30. (Total 31 QoS-groups).
- EXP marking using QoS policy is supported only on the outer label; inner EXP marking is not supported.

## How to Configure Multiprotocol Label Switching

This section explains how to perform the basic configuration required to prepare a switch for MPLS switching and forwarding.

### Configuring a Switch for MPLS Switching (CLI)

MPLS switching on Cisco switches requires that Cisco Express Forwarding be enabled.



---

**Note** `ip unnumbered` command is not supported in MPLS configuration.

---

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password, if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip cef distributed</b> <b>Example:</b> Device(config)# <b>ip cef distributed</b>	Enables Cisco Express Forwarding on the switch.
<b>Step 4</b>	<b>mpls label range</b> <i>minimum-value</i> <i>maximum-value</i> <b>Example:</b> Device(config)# <b>mpls label range 16 4096</b>	Configure the range of local labels available for use with MPLS applications on packet interfaces.
<b>Step 5</b>	<b>mpls label protocol ldp</b> <b>Example:</b> Device(config)# <b>mpls label protocol ldp</b>	Specifies the label distribution protocol for the platform.

## Configuring a Switch for MPLS Forwarding (CLI)

MPLS forwarding on Cisco switches requires that forwarding of IPv4 packets be enabled.



**Note** **ip unnumbered** command is not supported in MPLS configuration.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password, if prompted.



	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface type slot/subslot /port</b> <b>Example:</b>  Device(config)# interface gigabitethernet 1/0/0	Specifies the Gigabit Ethernet interface and enters interface configuration mode. For Switch Virtual Interface (SVI), the example is  Device(config)# interface vlan 1000
<b>Step 4</b>	<b>mpls ip</b> <b>Example:</b>  Device(config-if)# mpls ip	Enables MPLS forwarding of IPv4 packets along routed physical interfaces (Gigabit Ethernet), Switch Virtual Interface (SVI), or port channels.
<b>Step 5</b>	<b>mpls label protocol ldp</b> <b>Example:</b>  Device(config-if)# mpls label protocol ldp	Specifies the label distribution protocol for an interface.  <b>Note</b> MPLS LDP cannot be enabled on a Virtual Routing and Forwarding (VRF) interface.
<b>Step 6</b>	<b>end</b> <b>Example:</b>  Device(config-if)# end	Exits interface configuration mode and returns to privileged EXEC mode.

## Verifying Multiprotocol Label Switching Configuration

This section explains how to verify successful configuration of MPLS switching and forwarding.

### Verifying Configuration of MPLS Switching

To verify that Cisco Express Forwarding has been configured properly, issue the **show ip cef summary** command, which generates output similar to that shown below:

#### Procedure

---

```
show ip cef summary
```

#### Example:

```
Switch# show ip cef summary

IPv4 CEF is enabled for distributed and running
```

```

VRF Default
 150 prefixes (149/1 fwd/non-fwd)
Table id 0x0
Database epoch:      4 (150 entries at this epoch)
Switch#

```

---

## Verifying Configuration of MPLS Forwarding

To verify that MPLS forwarding has been configured properly, issue the **show mpls interfaces detail** command, which generates output similar to that shown below:



**Note** The MPLS MTU value is equivalent to the IP MTU value of the port or switch by default. MTU configuration for MPLS is not supported.

---

### Procedure

---

#### Step 1 show mpls interfaces detail

##### Example:

For physical (Gigabit Ethernet) interface:  
Switch# **show mpls interfaces detail interface GigabitEthernet 1/0/0**

```

Type Unknown
IP labeling enabled
LSP Tunnel labeling not enabled
IP FRR labeling not enabled
BGP labeling not enabled
MPLS not operational
MTU = 1500

```

For Switch Virtual Interface (SVI):  
Switch# **show mpls interfaces detail interface Vlan1000**

```

Type Unknown
IP labeling enabled (ldp) :
  Interface config
LSP Tunnel labeling not enabled
IP FRR labeling not enabled
BGP labeling not enabled
MPLS operational
MTU = 1500

```

#### Step 2 show running-config interface

##### Example:

For physical (Gigabit Ethernet) interface:  
Switch# **show running-config interface interface GigabitEthernet 1/0/0**

Building configuration...

```

Current configuration : 307 bytes
!
interface TenGigabitEthernet1/0/0
no switchport
ip address xx.xx.x.x xxx.xxx.xxx.x
mpls ip
mpls label protocol ldp
end

```

For Switch Virtual Interface (SVI):  
Switch# **show running-config interface interface Vlan1000**

Building configuration...

```

Current configuration : 187 bytes
!
interface Vlan1000
ip address xx.xx.x.x xxx.xxx.xxx.x
mpls ip
mpls label protocol ldp
end

```

### Step 3 show mpls forwarding

#### Example:

For physical (Gigabit Ethernet) interface:

```

Switch#show mpls forwarding-table
Local   Outgoing   Prefix           Bytes Label   Outgoing   Next Hop
Label   Label      or Tunnel Id     Switched      interface
500     No Label   12ckt(3)         0             Gi3/0/22   point2point
501     No Label   12ckt(1)         12310411816789 none         point2point
502     No Label   12ckt(2)         0             none        point2point
503     566       15.15.15.15/32   0             Po5         192.1.1.2
504     530       7.7.7.7/32       538728528     Po5         192.1.1.2
505     573       6.6.6.10/32      0             Po5         192.1.1.2
506     606       6.6.6.6/32       0             Po5         192.1.1.2
507     explicit-n 1.1.1.1/32       0             Po5         192.1.1.2
556     543       19.10.1.0/24     0             Po5         192.1.1.2
567     568       20.1.1.0/24     0             Po5         192.1.1.2
568     574       21.1.1.0/24     0             Po5         192.1.1.2
574     No Label   213.1.1.0/24[V] 0             aggregate/vpn113
575     No Label   213.1.2.0/24[V] 0             aggregate/vpn114
576     No Label   213.1.3.0/24[V] 0             aggregate/vpn115
577     No Label   213:1:1::/64    0             aggregate
594     502       103.1.1.0/24    0             Po5         192.1.1.2
595     509       31.1.1.0/24     0             Po5         192.1.1.2
596     539       15.15.1.0/24    0             Po5         192.1.1.2
597     550       14.14.1.0/24    0             Po5         192.1.1.2
633     614       2.2.2.0/24      0             Po5         192.1.1.2
634     577       90.90.90.90/32  873684        Po5         192.1.1.2
635     608       154.1.1.0/24    0             Po5         192.1.1.2
636     609       153.1.1.0/24    0             Po5         192.1.1.2
Switch#
end

```





## CHAPTER 67

# Configuring Multicast Virtual Private Network

- [Configuring Multicast VPN, on page 983](#)

## Configuring Multicast VPN

The Multicast VPN (MVPN) feature provides the ability to support multicast over a Layer 3 VPN. As enterprises extend the reach of their multicast applications, service providers can accommodate them over their Multiprotocol Label Switching (MPLS) core network. IP multicast is used to stream video, voice, and data over an MPLS VPN network core.

Historically, point-to-point tunnels were the only way to connect through a service provider network. Although such tunneled networks tend to have scalability issues, they represented the only means of passing IP multicast traffic through a VPN.

Because Layer 3 VPNs support only unicast traffic connectivity, deploying MPLS in conjunction with a Layer 3 VPN allows service providers to offer both unicast and multicast connectivity to Layer 3 VPN customers.

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Configuring Multicast VPN

Enable IP multicast and configure the PIM interfaces using the tasks described in the “Configuring Basic IP Multicast” module.

## Restrictions for Configuring Multicast VPN

- The update source interface for the Border Gateway Protocol (BGP) peerings must be the same for all BGP peerings configured on the device in order for the default multicast distribution tree (MDT) to be

configured properly. If you use a loopback address for BGP peering, PIM sparse mode must be enabled on the loopback address.

- MVPN does not support multiple BGP peering update sources.
- Multiple BGP update sources are not supported, and configuring them can break MVPN reverse path forwarding (RPF) checking. The source IP address of the MVPN tunnels is determined by the highest IP address used for the BGP peering update source. If this IP address is not the IP address used as the BGP peering address with the remote provider edge (PE) device, MVPN will not function properly.

## Information About Configuring Multicast VPN

### Multicast VPN Operation

MVPN IP allows a service provider to configure and support multicast traffic in an MPLS VPN environment. This feature supports routing and forwarding of multicast packets for each individual VRF instance, and it also provides a mechanism to transport VPN multicast packets across the service provider backbone.

A VPN is network connectivity across a shared infrastructure, such as an ISP. Its function is to provide the same policies and performance as a private network, at a reduced cost of ownership, thus creating many opportunities for cost savings through operations and infrastructure.

An MVPN allows an enterprise to transparently interconnect its private network across the network backbone of a service provider. The use of an MVPN to interconnect an enterprise network in this way does not change the way that enterprise network is administered, nor does it change general enterprise connectivity.

### Benefits of Multicast VPN

- Provides a scalable method to dynamically send information to multiple locations.
- Provides high-speed information delivery.
- Provides connectivity through a shared infrastructure.

### Multicast VPN Routing and Forwarding and Multicast Domains

MVPN introduces multicast routing information to the VPN routing and forwarding table. When a provider edge (PE) device receives multicast data or control packets from a customer edge (CE) router, forwarding is performed according to the information in the Multicast VPN routing and forwarding instance (MVRF). MVPN does not use label switching.

A set of MVRFs that can send multicast traffic to each other constitutes a multicast domain. For example, the multicast domain for a customer that wanted to send certain types of multicast traffic to all global employees would consist of all CE routers associated with that enterprise.

### Multicast Distribution Trees

MVPN establishes a static default multicast distribution tree (MDT) for each multicast domain. The default MDT defines the path used by PE routers to send multicast data and control messages to every other PE router in the multicast domain.

If Source Specific Multicast (SSM) is used as the core multicast routing protocol, the multicast IP addresses used for the default and data MDT must be configured within the SSM range on all PE routers.

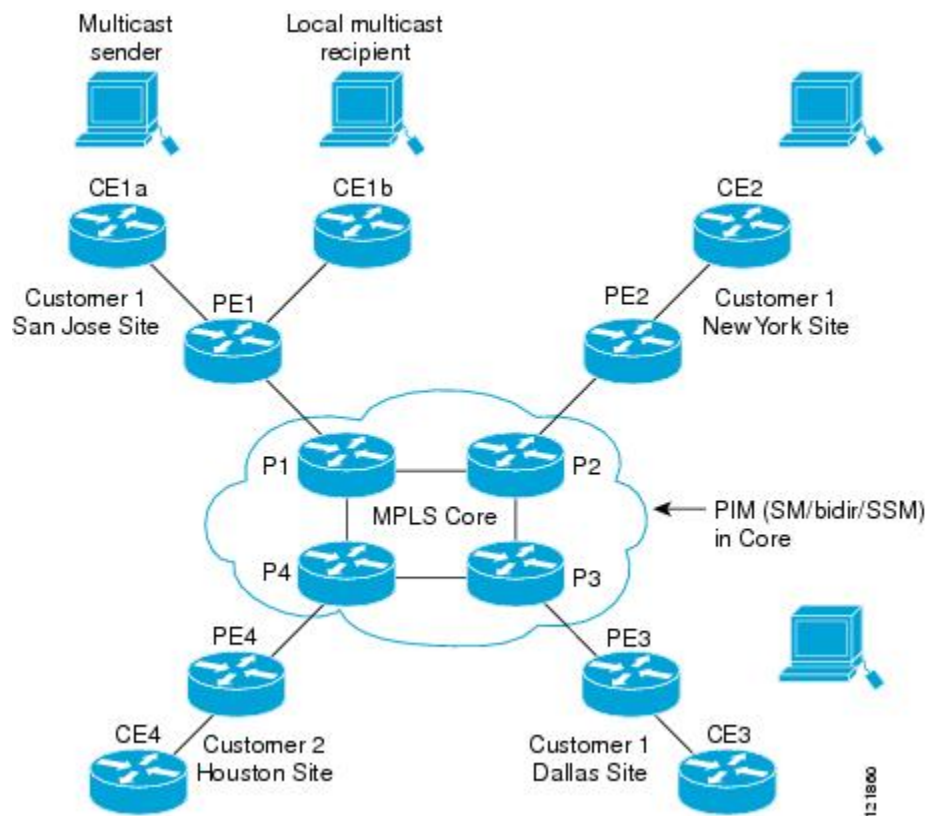
MVPN also supports the dynamic creation of MDTs for high-bandwidth transmission. Data MDTs are a feature unique to Cisco IOS software. Data MDTs are intended for high-bandwidth sources such as full-motion video inside the VPN to ensure optimal traffic forwarding in the MPLS VPN core. The threshold at which the data MDT is created can be configured on a per-router or a per-VRF basis. When the multicast transmission exceeds the defined threshold, the sending PE router creates the data MDT and sends a UDP message, which contains information about the data MDT, to all routers on the default MDT. The statistics to determine whether a multicast stream has exceeded the data MDT threshold are examined once every second. After a PE router sends the UDP message, it waits 3 more seconds before switching over; 13 seconds is the worst case switchover time, and 3 seconds is the best case.

Data MDTs are created only for (S, G) multicast route entries within the VRF multicast routing table. They are not created for (\*, G) entries regardless of the value of the individual source data rate.

In the following example, a service provider has a multicast customer with offices in San Jose, New York, and Dallas. A one-way multicast presentation is occurring in San Jose. The service provider network supports all three sites associated with this customer, in addition to the Houston site of a different enterprise customer.

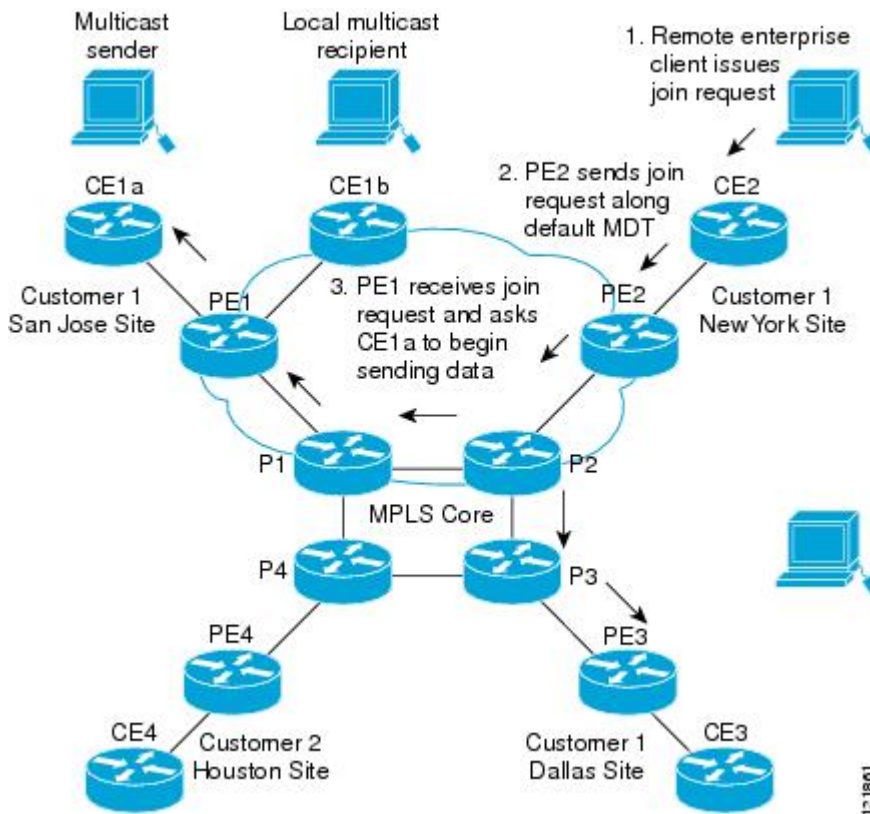
The default MDT for the enterprise customer consists of provider routers P1, P2, and P3 and their associated PE routers. PE4 is not part of the default MDT, because it is associated with a different customer. The figure shows that no data flows along the default MDT, because no one outside of San Jose has joined the multicast.

**Figure 76: Default Multicast Distribution Tree Overview**



An employee in New York joins the multicast session. The PE router associated with the New York site sends a join request that flows across the default MDT for the multicast domain of the customer. PE1, the PE router associated with the multicast session source, receives the request. The figure depicts that the PE router forwards the request to the CE router associated with the multicast source (CE1a).

Figure 77: Initializing the Data MDT



The CE router (CE1a) begins to send the multicast data to the associated PE router (PE1), which sends the multicast data along the default MDT. Immediately sending the multicast data, PE1 recognizes that the multicast data exceeds the bandwidth threshold for which a data MDT should be created. Therefore, PE1 creates a data MDT, sends a message to all routers using the default MDT, which contains information about the data MDT, and, three seconds later, begins sending the multicast data for that particular stream using the data MDT. Only PE2 has interested receivers for this source, so only PE2 will join the data MDT and receive traffic on it.

PE routers maintain a PIM relationship with other PE routers over the default MDT and a PIM relationship with directly attached PE routers.

## Multicast Tunnel Interface

An MVRF, which is created per multicast domain, requires the device to create a tunnel interface from which all MVRF traffic is sourced. A multicast tunnel interface is an interface that the MVRF uses to access the multicast domain. It can be thought of as a conduit that connects an MVRF and the global MVRF. One tunnel interface is created per MVRF.

## MDT Address Family in BGP for Multicast VPN

The **mdt** keyword has been added to the **address-family ipv4** command to configure an MDT address-family session. MDT address-family sessions are used to pass the source PE address and MDT group address to PIM using Border Gateway Protocol (BGP) MDT Subaddress Family Identifier (SAFI) updates.



## BGP Advertisement Methods for Multicast VPN Support

In a single autonomous system, if the default MDT for an MVPN is using PIM sparse mode (PIM-SM) with a rendezvous point (RP), then PIM is able to establish adjacencies over the Multicast Tunnel Interface (MTI) because the source PE and receiver PE discover each other through the RP. In this scenario, the local PE (the source PE) sends register messages to the RP, which then builds a shortest-path tree (SPT) toward the source PE. The remote PE, which acts as a receiver for the MDT multicast group, then sends (\*, G) joins toward the RP and joins the distribution tree for that group.

However, if the default MDT group is configured in a PIM Source Specific Multicast (PIM-SSM) environment rather than a PIM-SM environment, the receiver PE needs information about the source PE and the default MDT group. This information is used to send (S, G) joins toward the source PE to build a distribution tree from the source PE (without the need for an RP). The source PE address and default MDT group address are sent using BGP.

### BGP Extended Community

When BGP extended communities are used, the PE loopback (source address) information is sent as a VPNv4 prefix using Route Distinguisher (RD) Type 2 (to distinguish it from unicast VPNv4 prefixes). The MDT group address is carried in a BGP extended community. Using a combination of the embedded source in the VPNv4 address and the group in the extended community, PE routers in the same MVRF instance can establish SSM trees to each other.



**Note** Prior to the introduction of MDT SAFI support, the BGP extended community attribute was used as an interim solution to advertise the IP address of the source PE and default MDT group before IETF standardization. A BGP extended community attribute in an MVPN environment, however, has certain limitations: it cannot be used in inter-AS scenarios (because the attribute is nontransitive), and it uses RD Type 2 (which is not a supported standard).

## How to Configure Multicast VPN

### Configuring the Data Multicast Group

A data MDT group can include a maximum of 256 multicast groups per VPN per VRF per PE device. Multicast groups used to create the data MDT group are dynamically chosen from a pool of configured IP addresses. Use the following procedure to configure data multicast group on the device.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# configure terminal	
<b>Step 3</b>	<b>vrf definition</b> <i>vrf-name</i> <b>Example:</b> Device(config)# vrf definition vrf1	Enters VRF configuration mode and defines the VPN routing instance by assigning a VRF name.
<b>Step 4</b>	<b>rd</b> <i>route-distinguisher</i> <b>Example:</b> Device(config-vrf)# rd 1:1	Creates routing and forwarding tables for a VRF. <ul style="list-style-type: none"> <li>• The <i>route-distinguisher</i> argument specifies to add an 8-byte value to an IPv4 prefix to create a VPN IPv4 prefix. You can enter a <i>route-distinguisher</i> in either of these formats:</li> <li>• 16-bit autonomous system number (ASN): your 32-bit number. For example, 101:3.</li> <li>• 32-bit IP address: your 16-bit number. For example, 192.168.122.15:1.</li> </ul>
<b>Step 5</b>	<b>route-target both</b> <i>ASN:nn or IP-address:nn</i> <b>Example:</b> Device(config-vrf)# route-target both 1:1	Creates a route-target extended community for a VRF. The <b>both</b> keyword specifies to import both import and export routing information to the target VPN extended community.
<b>Step 6</b>	<b>address family ipv4 unicast</b> <i>value</i> <b>Example:</b> Device(config-vrf)# address family ipv4 unicast	Enters VRF address family configuration mode to specify an address family for a VRF. <ul style="list-style-type: none"> <li>• The <b>ipv4</b> keyword specifies an IPv4 address family for a VRF</li> </ul>
<b>Step 7</b>	<b>mdt default</b> <i>group-address</i> <b>Example:</b> Device(config-vrf-af)# mdt default 226.10.10.10	Configures the multicast group address range for data MDT groups for a VRF. <ul style="list-style-type: none"> <li>• A tunnel interface is created as a result of this command.</li> <li>• The default MDT group address configuration must be the same on all PEs in the same VRF.</li> </ul>
<b>Step 8</b>	<b>mdt data</b> <i>group number</i> <b>Example:</b> Device(config-vrf-af)# mdt data 232.0.1.0 0.0.0.31	Specifies a range of addresses to be used in the data MDT pool.

	Command or Action	Purpose
<b>Step 9</b>	<b>mdt data threshold <i>kbps</i></b> <b>Example:</b> <pre>Device(config-vrf-af)# mdt data threshold 50</pre>	Specifies the threshold in <i>kbps</i> . The range is from 1 to 4294967.
<b>Step 10</b>	<b>mdt log-reuse</b> <b>Example:</b> <pre>Device(config-vrf-af)# mdt log-reuse</pre>	(Optional) Enables the recording of data MDT reuse and generates a syslog message when a data MDT has been reused.
<b>Step 11</b>	<b>end</b> <b>Example:</b> <pre>Device(config-vrf-af)# end</pre>	Returns to privileged EXEC mode.

## Configuring a Default MDT Group for a VRF

Perform this task to configure a default MDT group for a VRF.

The default MDT group must be the same group configured on all devices that belong to the same VPN. The source IP address will be the address used to source the BGP sessions.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ip multicast-routing</b> <b>Example:</b> <pre>Device(config)# ip multicast-routing</pre>	Enables multicast routing.
<b>Step 4</b>	<b>ip multicast-routing vrf <i>vrf-name</i></b> <b>Example:</b> <pre>Device(config)# ip multicast-routing vrf vrf1</pre>	Supports the MVPN VRF instance.

	Command or Action	Purpose
<b>Step 5</b>	<b>vrf definition</b> <i>vrf-name</i> <b>Example:</b> <pre>Device(config)# vrf definition vrf1</pre>	Enters VRF configuration mode and defines the VPN routing instance by assigning a VRF name.
<b>Step 6</b>	<b>rd</b> <i>route-distinguisher</i> <b>Example:</b> <pre>Device(config-vrf)# rd 1:1</pre>	Creates routing and forwarding tables for a VRF. <ul style="list-style-type: none"> <li>• The <i>route-distinguisher</i> argument specifies to add an 8-byte value to an IPv4 prefix to create a VPN IPv4 prefix. You can enter a <i>route-distinguisher</i> in either of these formats:</li> <li>• 16-bit autonomous system number (ASN): your 32-bit number. For example, 101:3.</li> <li>• 32-bit IP address: your 16-bit number. For example, 192.168.122.15:1.</li> </ul>
<b>Step 7</b>	<b>route-target both</b> <i>ASN:nn or IP-address:nn</i> <b>Example:</b> <pre>Device(config-vrf)# route-target both 1:1</pre>	Creates a route-target extended community for a VRF. The <b>both</b> keyword specifies to import both import and export routing information to the target VPN extended community.
<b>Step 8</b>	<b>address family ipv4 unicast</b> <i>value</i> <b>Example:</b> <pre>Device(config-vrf)# address family ipv4 unicast</pre>	Enters VRF address family configuration mode to specify an address family for a VRF. <ul style="list-style-type: none"> <li>• The <b>ipv4</b> keyword specifies an IPv4 address family for a VRF</li> </ul>
<b>Step 9</b>	<b>mdt default</b> <i>group-address</i> <b>Example:</b> <pre>Device(config-vrf-af)# mdt default 226.10.10.10</pre>	Configures the multicast group address range for data MDT groups for a VRF. <ul style="list-style-type: none"> <li>• A tunnel interface is created as a result of this command.</li> <li>• The default MDT group address configuration must be the same on all PEs in the same VRF.</li> </ul>
<b>Step 10</b>	<b>end</b> <b>Example:</b> <pre>Device(config-vrf-af)# end</pre>	Returns to privileged EXEC mode.
<b>Step 11</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# configure terminal	
<b>Step 12</b>	<b>ip pim vrf vrf-name rp-address value</b> <b>Example:</b> Device(config-vrf-af)# ip pim vrf vrf1 rp-address 1.1.1.1	Enters the RP configuration mode.

## Configuring the MDT Address Family in BGP for Multicast VPN

Perform this task to configure an MDT address family session on PE devices to establish MDT peering sessions for MVPN.

### Before you begin

Before MVPN peering can be established through an MDT address family, MPLS and Cisco Express Forwarding (CEF) must be configured in the BGP network and multiprotocol BGP on PE devices that provide VPN services to CE devices.



**Note** The following policy configuration parameters are not supported:

- Route-originator attribute
- Network Layer Reachability Information (NLRI) prefix filtering (prefix lists, distribute lists)
- Extended community attributes (route target and site of origin)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>router bgp as-number</b> <b>Example:</b> Device(config)# router bgp 65535	Enters router configuration mode and creates a BGP routing process.

	Command or Action	Purpose
<b>Step 4</b>	<b>address-family ipv4 mdt</b> <b>Example:</b>  Device(config-router)# address-family ipv4 mdt	Enters address family configuration mode to create an IP MDT address family session.
<b>Step 5</b>	<b>neighbor neighbor-address activate</b> <b>Example:</b>  Device(config-router-af)# neighbor 192.168.1.1 activate	Enables the MDT address family for this neighbor.
<b>Step 6</b>	<b>neighbor neighbor-address send-community [both   extended   standard]</b> <b>Example:</b>  Device(config-router-af)# neighbor 192.168.1.1 send-community extended	Enables community and (or) extended community exchange with the specified neighbor.
<b>Step 7</b>	<b>exit</b> <b>Example:</b>  Device(config-router-af)# exit	Exits address family configuration mode and returns to router configuration mode.
<b>Step 8</b>	<b>address-family vpnv4</b> <b>Example:</b>  Device(config-router)# address-family vpnv4	Enters address family configuration mode to create a VPNv4 address family session.
<b>Step 9</b>	<b>neighbor neighbor-address activate</b> <b>Example:</b>  Device(config-router-af)# neighbor 192.168.1.1 activate	Enables the VPNv4 address family for this neighbor.
<b>Step 10</b>	<b>neighbor neighbor-address send-community [both   extended   standard]</b> <b>Example:</b>  Device(config-router-af)# neighbor 192.168.1.1 send-community extended	Enables community and (or) extended community exchange with the specified neighbor.
<b>Step 11</b>	<b>end</b> <b>Example:</b>  Device(config-router-af)# end	Exits address family configuration mode and enters privileged EXEC mode.

## Verifying Information for the MDT Default Group

### Procedure

#### Step 1

**enable**

**Example:**

```
Device> enable
```

Enables privileged EXEC mode.

- Enter your password if prompted.

#### Step 2

**show ip pim [vrf *vrf-name*] mdt bgp**

**Example:**

```
Device# show ip pim mdt bgp
```

```
MDT-default group 232.2.1.4
rid:1.1.1.1 next_hop:1.1.1.1
```

Displays information about the BGP advertisement of the RD for the MDT default group.

#### Step 3

**show ip pim [vrf *vrf-name*] mdt send**

**Example:**

```
Device# show ip pim mdt send
```

```
MDT-data send list for VRF:vpn8
(source, group)                MDT-data group    ref_count
(10.100.8.10, 225.1.8.1)        232.2.8.0         1
(10.100.8.10, 225.1.8.2)        232.2.8.1         1
(10.100.8.10, 225.1.8.3)        232.2.8.2         1
(10.100.8.10, 225.1.8.4)        232.2.8.3         1
(10.100.8.10, 225.1.8.5)        232.2.8.4         1
(10.100.8.10, 225.1.8.6)        232.2.8.5         1
(10.100.8.10, 225.1.8.7)        232.2.8.6         1
(10.100.8.10, 225.1.8.8)        232.2.8.7         1
(10.100.8.10, 225.1.8.9)        232.2.8.8         1
(10.100.8.10, 225.1.8.10)       232.2.8.9         1
```

Displays detailed information about the MDT data group including MDT advertisements that the specified device has made.

#### Step 4

**show ip pim vrf *vrf-name* mdt history interval *minutes***

**Example:**

```
Device# show ip pim vrf vrf1 mdt history interval 20
```

```
MDT-data send history for VRF - vrf1 for the past 20 minutes
MDT-data group    Number of reuse
10.9.9.8          3
10.9.9.9          2
```

Displays the data MDTs that have been reused during the past configured interval.

## Configuration Examples for Multicast VPN

### Example: Configuring MVPN and SSM

In the following example, PIM-SSM is configured in the backbone. Therefore, the default and data MDT groups are configured within the SSM range of IP addresses. Inside the VPN, PIM-SM is configured and only Auto-RP announcements are accepted.

```
ip vrf vrf1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
 mdt default 232.0.0.1
 mdt data 232.0.1.0 0.0.0.255 threshold 500 list 101
!
ip pim ssm default
ip pim vrf vrf1 accept-rp auto-rp
```

### Example: Enabling a VPN for Multicast Routing

In the following example, multicast routing is enabled with a VPN routing instance named vrf1:

```
ip multicast-routing vrf1
```

### Example: Configuring the Multicast Group Address Range for Data MDT Groups

In the following example, the VPN routing instance is assigned a VRF named blue. The MDT default group for a VPN VRF is 239.1.1.1, and the multicast group address range for MDT groups is 239.1.2.0 with wildcard bits of 0.0.0.3:

```
ip vrf blue
 rd 55:1111
 route-target both 55:1111
 mdt default 239.1.1.1
 mdt data 239.1.2.0 0.0.0.3
end
```

### Example: Limiting the Number of Multicast Routes

In the following example, the number of multicast routes that can be added to a multicast routing table is set to 200,000 and the threshold value of the number of mroutes that will cause a warning message to occur is set to 20,000:

```
!
ip multicast-routing
ip multicast-routing vrf cisco
ip multicast cache-headers
ip multicast route-limit 200000 20000
ip multicast vrf cisco route-limit 200000 20000
no mpls traffic-eng auto-bw timers frequency 0
!
```



## Additional References for Configuring Multicast VPN

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Command List, All Releases</a>
For complete syntax and usage information for the commands used in this chapter.	

### Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>





## PART **XII**

# Network Management

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## CHAPTER 68

# Configuring Autoconf

Autoconf is a solution that can be used to manage port configurations for data or voice VLAN, quality of service (QoS) parameters, storm control, and MAC-based port security on end devices that are deployed in the access layer of a network.

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## Prerequisites for Autoconf

- Before enabling Autoconf, disable the Auto SmartPort (ASP) macro, device classifier, and then access the session monitor.

## Restrictions for Autoconf

- ASP macro and Autoconf are not supported on the same interface at the same time. Either Autoconf or ASP must be disabled on a per-interface level.
- Interface templates are not applicable for wireless sessions.
- When the Autoconf feature is enabled using the **autoconf enable** command, the default Autoconf service policy is applied to all interfaces. No other service policy can be applied globally using the **service-policy** command. To apply a different service policy, you must disable Autoconf on that interface. When a service policy is applied globally, you must disable it before enabling the Autoconf feature.
- When both local (interface-level) and global service policies exist, the local policy take precedence. Events in the local service policy are handled and the global service policy is not applied. The global service policy comes into effect only when the local policy is removed.
- Service templates cannot be applied to interfaces, and interface templates cannot be applied to service instances.

- Only one service template can be nested inside an interface template.

## Information About Autoconf

### Benefits of Autoconf

The Autoconf feature permits hardbinding between the end device and the interface. Autoconf falls under the umbrella of the Smart Operations solution. Smart Operations is a comprehensive set of capabilities that can simplify and improve LAN switch deployment. Smart Operations help organizations deliver operational excellence and scale services on the network.

The Autoconf feature automatically applies the needed configurations on the device ports to enable the efficient performance of each directly connected end device using a set of interface configurations that are configured inside an interface template.

- Autoconf efficiently applies commands to an interface because the parser does not need to parse each command each time.
- Configurations that are applied through the Autoconf feature can be reliably removed from a port without impacting previous or subsequent configurations on the port.
- The Autoconf feature provides built-in and user-defined configurations using interface and service templates. Configurations applied through templates can be centrally updated with a single operation.
- Using the Autoconf feature, a configuration can be applied to ports and access sessions.
- The Autoconf feature reduces ongoing maintenance for devices and attached end devices by making them intuitive and autoconfigurable. This reduces operation expenses (OPEX) and lowers the total cost of ownership (TCO).

### Identity Session Management and Templates

A key advantage of the Autoconf feature is that the core session management capability is decoupled from the application-specific logic; thus, allowing the same framework to be used regardless of the criteria for policy determination or the nature of the policies applied.

The identity session management infrastructure allows configurations and/or policies to be applied as templates.

Both service and interface templates are named containers of configuration and policy. Service templates may be applied only to access sessions, while interface templates may be applied only to ports. When a service template is applied to an access session, the contained configuration/policy is applied only to the target session and has no impact on other sessions that may be hosted on the same access port. Similarly, when an interface template is applied to an access port, it impacts all traffic exchanged on the port.

The Autoconf feature uses a set of built-in maps and built-in templates. The built-in templates are designed based on best practices for interface configurations. Built-in templates can be modified by the user to include customized configurations, limiting the need to create a new template.

The templates created by users are referred to as user-defined templates. User-defined templates can be defined on the device and can be mapped to any built-in or user-defined trigger.

Use the **show derived-config** command, to view the overall applied configurations applied by Autoconf template and manual configuration. The interface commands shown in the output of **show running-config interface type number** command are not necessarily the operational configuration. The Autoconf feature

dynamically applies a template to the interface, and overrides any conflicting static configuration that is already applied.

## Autoconf Operation

Autoconf uses the Device Classifier to identify the end devices that are connected to a port.

The Autoconf feature uses the device classification information gleaned from Cisco Discovery Protocol, LLDP, DHCP, MAC addresses, and the Organizationally Unique Identifier (OUI) that is identified by the Device Classifier.

The Device Classifier provides improved device classification capabilities and accuracy, and increased device visibility for enhanced configuration management.

Device classification is enabled when you enable the Autoconf feature using **autoconf enable** command in global configuration mode .

The device detection acts as an event trigger, which in turn applies the appropriate automatic template to the interface.

The Autoconf feature is based on a three-tier hierarchy.

- A policy map identifies the trigger type for applying the Autoconf feature.
- A parameter map identifies the appropriate template that must be applied, based on the end device.
- The templates contain the configurations to be applied.

The Autoconf built-in templates and triggers perform the these three steps automatically.

The Autoconf feature provides the following built-in templates:

- AP\_INTERFACE\_TEMPLATE
- DMP\_INTERFACE\_TEMPLATE
- IP\_CAMERA\_INTERFACE\_TEMPLATE
- IP\_PHONE\_INTERFACE\_TEMPLATE
- LAP\_INTERFACE\_TEMPLATE
- MSP\_CAMERA\_INTERFACE\_TEMPLATE
- MSP\_VC\_INTERFACE\_TEMPLATE
- PRINTER\_INTERFACE\_TEMPLATE
- ROUTER\_INTERFACE\_TEMPLATE
- SWITCH\_INTERFACE\_TEMPLATE
- TP\_INTERFACE\_TEMPLATE



---

**Note** By default built-in templates are not displayed under running configuration. The built-in templates show in the running configuration only if you edit them.

---

The template that is selected is based on parameter map information applied to an interface. This information can be based on the following criteria:

- End Device type
- MAC address
- OUI
- User role
- Username

The Autoconf feature provides one built-in parameter map `BUILTIN_DEVICE_TO_TEMPLATE` with the following configuration:

```
Parameter-map name: BUILTIN_DEVICE_TO_TEMPLATE
Map: 10 map device-type regex "Cisco-IP-Phone"
  Action(s):
    20 interface-template IP_PHONE_INTERFACE_TEMPLATE
Map: 20 map device-type regex "Cisco-IP-Camera"
  Action(s):
    20 interface-template IP_CAMERA_INTERFACE_TEMPLATE
Map: 30 map device-type regex "Cisco-DMP"
  Action(s):
    20 interface-template DMP_INTERFACE_TEMPLATE
Map: 40 map oui eq "00.0f.44"
  Action(s):
    20 interface-template DMP_INTERFACE_TEMPLATE
Map: 50 map oui eq "00.23.ac"
  Action(s):
    20 interface-template DMP_INTERFACE_TEMPLATE
Map: 60 map device-type regex "Cisco-AIR-AP"
  Action(s):
    20 interface-template AP_INTERFACE_TEMPLATE
Map: 70 map device-type regex "Cisco-AIR-LAP"
  Action(s):
    20 interface-template LAP_INTERFACE_TEMPLATE
Map: 80 map device-type regex "Cisco-TelePresence"
  Action(s):
    20 interface-template TP_INTERFACE_TEMPLATE
Map: 90 map device-type regex "Surveillance-Camera"
  Action(s):
    10 interface-template MSP_CAMERA_INTERFACE_TEMPLATE
Map: 100 map device-type regex "Video-Conference"
  Action(s):
    10 interface-template MSP_VC_INTERFACE_TEMPLATE
```




---

**Note** Use the `show parameter-map type subscriber attribute-to-service All` command to view the configuration for the built-in parameter map.

---

The Autoconf feature provides one built-in policy map `BUILTIN_AUTOCONF_POLICY` with the following configuration:

```
BUILTIN_AUTOCONF_POLICY
  event identity-update match-all
    10 class always do-until-failure
      10 map attribute-to-service table BUILTIN_DEVICE_TO_TEMPLATE
```





**Note** Use the **show policy-map type control subscriber BUILTIN\_AUTOCONF\_POLICY** command to view the configuration for the built-in policy map.

You can also manually create policy maps, parameter maps, and templates.

When a trigger is created that is based on specific user information, a local 802.1X Cisco Identity Services Engine (ISE) server authenticates it ensuring the security of the operation.

An interface template can be dynamically activated (on an interface) using any of the following methods:

- RADIUS CoA—While Change of Authorization (CoA) commands are targeted to one or more access sessions, any referenced template must be applied to the interface hosting the referenced session.
- RADIUS Access-Accept for client authentication or authorization—Any referenced interface template returned in an Access-Accept must be applied to the port that is hosting the authorized access session.
- Service template—If an interface template is referenced in a service template that is either locally defined or sourced from the AAA server, the interface template must be applied to the interface hosting any access-session on which the service template is applied (add a new command for interface template reference from within a locally defined service template).
- Subscriber control-policy action—A mapping action under the subscriber control policy activates service and/or interface template (as referenced in a parameter map) based on the type of filter, and removes any templates associated with a previous policy.
- Device-to-template parameter map—A subscriber parameter map that allows the filter type to service and/or interface template mappings to be specified in an efficient and readable manner.

## Advantages of Using Templates

Using templates for autoconfiguration has the following benefits:

- Templates are parsed once when they are being defined. This makes dynamic application of the templates very efficient.
- Templates can be applied to an Ethernet interface that is connected to an end device, based on the type of the end device.
- Service templates allow the activation of session-oriented features, whereas interface templates apply configurations to the interface that is hosting a session.
- Service templates are applied to access sessions and hence only impact the traffic exchanged with a single endpoint on a port.
- Startup and running configurations of the device are not modified by the dynamic application of the template.
- Policy application is synchronized with the access-session life cycle, which is tracked by the framework by using all available techniques, including just link-up/link-down.
- Templates can be updated with a single operation. All applied instances of the templates are updated.
- Constituent commands of the templates do not appear in the running configuration.
- Templates can be removed with no impact on previous or subsequent configurations.

- Template application is acknowledged, allowing for synchronization and performing remedial actions where failures occur.
- Data VLAN, quality of service (QoS) parameters, storm control, and MAC-based port security are configured automatically based on the end device that is connected to the switch.
- The switch port is cleaned up completely by removing configurations when the device is disconnected from a port.
- Human error is reduced in the installation and configuration process.

## Autoconf Functionality

The Autoconf feature is disabled by default in global configuration mode. When you enable the Autoconf feature in global configuration mode, it is enabled by default at the interface level. The built-in template configurations are applied based on the end devices detected on all interfaces.

Use the **access-session inherit disable autoconf** command to manually disable Autoconf at the interface level, even when Autoconf is enabled at the global level.

If you disable Autoconf at the global level, all interface-level configurations are disabled.

Global	Interface Level	AutoConf Status
Disable	Disable	No automatic configurations are applied when an end device is connected.
Enable	Enabled by default	If Autoconf is enabled at the global level, it is enabled at the interface level by default. Built-in template configurations are applied based on the end devices that are detected on all interfaces.
Enable	Disable	Enabled at global level. Disabled at interface level. No automatic configurations are applied when an end device is connected to the interface on which Autoconf is disabled.

Autoconf allows you to retain the template even when the link to the end device is down or the end device is disconnected, by configuring the Autoconf sticky feature. Use the **access-session interface-template sticky** command to configure the Autoconf sticky feature in global configuration mode. The Autoconf sticky feature avoids the need for detecting the end device and applying the template every time the link flaps or device is removed and connected back.

The **access-session interface-template sticky** command is mandatory to apply an inbuilt template that contains **access-session** commands on an interface. Configure the **access-session interface-template sticky** command to apply interface template on a port using a service policy.

If you want to disable the Autoconf feature on a specific interface, use the **access-session inherit disable interface-template-sticky** command in interface configuration mode.

# How to Configure Autoconf

## Applying a Built-in Template to an End Device

The following task shows how to apply a built-in template on an interface that is connected to an end device, for example, a Cisco IP phone.

### Before you begin

Make sure that the end device, for example, a Cisco IP phone, is connected to the switch port.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"><li>• Enter your password if prompted.</li></ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device(config)# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>autoconf enable</b> <b>Example:</b> Device(config)# autoconf enable	Enables the Autoconf feature.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# end	Exits global configuration mode and enters privileged EXEC mode.
<b>Step 5</b>	(Optional) <b>show device classifier attached interface</b> <i>interface-type interface-number</i> <b>Example:</b> Device# show device classifier attached interface Gi3/0/26	Displays whether the end device is classified by the device classifier with correct attributes.
<b>Step 6</b>	<b>show template binding target</b> <i>interface-type interface-number</i> <b>Example:</b> Device# show template binding target gi3/0/26	Displays the configuration applied through the template on the interface.

## Verifying the device classification of an End Device

### Verifying the Interface Template on an Interface

### Verifying the Interface Configuration

### Verifying Global Configuration after Applying Autoconf

The following example shows that an IP phone is classified by the Device Classifier with correct attributes:

```
Device# show device classifier attached interface GigabitEthernet 3/0/26
```

Summary:

MAC_Address	Port_Id	Profile Name	Device Name
0026.0bd9.7bbb	Gi3/0/26	Cisco-IP-Phone-7962	Cisco IP Phone 7962

The following example shows that a built-in interface template is applied on the interface:

```
Device# show template binding target GigabitEthernet 3/0/26
```

```
Interface Templates
=====
Interface: Gi4/0/11
Method          Source          Template-Name
-----          -
dynamic         Built-in        IP_PHONE_INTERFACE_TEMPLATE
```

The following example shows how to verify the interface configuration after the interface template is applied to the IP phone connected to the GigabitEthernet interface 3/0/26 :

```
Device# show running-config interface GigabitEthernet 3/0/26
```

Building configuration...

```
Current configuration : 624 bytes
!
interface GigabitEthernet3/0/26
!
End
```

```
Device# show derived-config interface GigabitEthernet 3/0/26
```

Building configuration...

```
Derived configuration : 649 bytes
!
interface GigabitEthernet3/0/26
  switchport mode access
  switchport block unicast
  switchport port-security maximum 3
  switchport port-security maximum 2 vlan access
  switchport port-security violation restrict
  switchport port-security aging time 2
  switchport port-security aging type inactivity
  switchport port-security
  load-interval 30
  storm-control broadcast level pps 1k
  storm-control multicast level pps 2k
  storm-control action trap
```

```
spanning-tree portfast
spanning-tree bpduguard enable
service-policy input AutoConf-4.0-CiscoPhone-Input-Policy
service-policy output AutoConf-4.0-Output-Policy
ip dhcp snooping limit rate 15
end

Device# show running config
class-map match-any AutoConf-4.0-Scavenger-Queue
  match dscp cs1
  match cos 1
  match access-group name AutoConf-4.0-ACL-Scavenger
class-map match-any AutoConf-4.0-VoIP
  match dscp ef
  match cos 5
class-map match-any AutoConf-4.0-Control-Mgmt-Queue
  match cos 3
  match dscp cs7
  match dscp cs6
  match dscp cs3
  match dscp cs2
  match access-group name AutoConf-4.0-ACL-Signaling
class-map match-any AutoConf-4.0-Multimedia-Conf
  match dscp af41
  match dscp af42
  match dscp af43
class-map match-all AutoConf-4.0-Broadcast-Vid
  match dscp cs5
class-map match-any AutoConf-4.0-Bulk-Data
  match dscp af11
  match dscp af12
  match dscp af13
class-map match-all AutoConf-4.0-Realtime-Interact
  match dscp cs4
class-map match-any AutoConf-4.0-VoIP-Signal
  match dscp cs3
  match cos 3
class-map match-any AutoConf-4.0-Trans-Data-Queue
  match cos 2
  match dscp af21
  match dscp af22
  match dscp af23
  match access-group name AutoConf-4.0-ACL-Transactional-Data
class-map match-any AutoConf-4.0-VoIP-Data
  match dscp ef
  match cos 5
class-map match-any AutoConf-4.0-Multimedia-Stream
  match dscp af31
  match dscp af32
  match dscp af33
class-map match-all AutoConf-4.0-Internternet-Ctrl
  match dscp cs6
class-map match-all AutoConf-4.0-VoIP-Signal-Cos
  match cos 3
class-map match-any AutoConf-4.0-Multimedia-Stream-Queue
  match dscp af31
  match dscp af32
  match dscp af33
class-map match-all AutoConf-4.0-Network-Mgmt
  match dscp cs2
class-map match-all AutoConf-4.0-VoIP-Data-Cos
  match cos 5
class-map match-any AutoConf-4.0-Priority-Queue
  match cos 5
  match dscp ef
```

```

match dscp cs5
match dscp cs4
class-map match-any AutoConf-4.0-Bulk-Data-Queue
match cos 1
match dscp af11
match dscp af12
match dscp af13
match access-group name AutoConf-4.0-ACL-Bulk-Data
class-map match-any AutoConf-4.0-Transaction-Data
match dscp af21
match dscp af22
match dscp af23
class-map match-any AutoConf-4.0-Multimedia-Conf-Queue
match cos 4
match dscp af41
match dscp af42
match dscp af43
match access-group name AutoConf-4.0-ACL-Multimedia-Conf
class-map match-all AutoConf-4.0-Network-Ctrl
match dscp cs7
class-map match-all AutoConf-4.0-Scavenger
match dscp cs1
class-map match-any AutoConf-4.0-Signaling
match dscp cs3
match cos 3
!
!
policy-map AutoConf-4.0-Cisco-Phone-Input-Policy
class AutoConf-4.0-VoIP-Data-Cos
  set dscp ef
  police cir 128000 bc 8000
  exceed-action set-dscp-transmit cs1
  exceed-action set-cos-transmit 1
class AutoConf-4.0-VoIP-Signal-Cos
  set dscp cs3
  police cir 32000 bc 8000
  exceed-action set-dscp-transmit cs1
  exceed-action set-cos-transmit 1
class class-default
  set dscp default
  set cos 0
policy-map AutoConf-4.0-Output-Policy
class AutoConf-4.0-Scavenger-Queue
  bandwidth remaining percent 1
class AutoConf-4.0-Priority-Queue
  priority
  police cir percent 30 bc 33 ms
class AutoConf-4.0-Control-Mgmt-Queue
  bandwidth remaining percent 10
class AutoConf-4.0-Multimedia-Conf-Queue
  bandwidth remaining percent 10
class AutoConf-4.0-Multimedia-Stream-Queue
  bandwidth remaining percent 10
class AutoConf-4.0-Trans-Data-Queue
  bandwidth remaining percent 10
  dbl
class AutoConf-4.0-Bulk-Data-Queue
  bandwidth remaining percent 4
  dbl
class class-default
  bandwidth remaining percent 25
  dbl
policy-map AutoConf-DMP
class class-default

```

```

set dscp cs2
policy-map AutoConf-IPVSC
  class class-default
    set cos dscp table AutoConf-DscpToCos
policy-map AutoConf-4.0-Input-Policy
  class AutoConf-4.0-VoIP
  class AutoConf-4.0-Broadcast-Vid
  class AutoConf-4.0-Realtime-Interact
  class AutoConf-4.0-Network-Ctrl
  class AutoConf-4.0-Internetwork-Ctrl
  class AutoConf-4.0-Signaling
  class AutoConf-4.0-Network-Mgmt
  class AutoConf-4.0-Multimedia-Conf
  class AutoConf-4.0-Multimedia-Stream
  class AutoConf-4.0-Transaction-Data
  class AutoConf-4.0-Bulk-Data
  class AutoConf-4.0-Scavenger

```

## Applying a Modified Built-in Template to an End Device

The following task shows how to modify a built-in template when multiple wireless access points and IP cameras are connected to a switch.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"><li>• Enter your password if prompted.</li></ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device(config)# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>template <i>template-name</i></b> <b>Example:</b> Device(config)# template AP_INTERFACE_TEMPLATE	Enters template configuration mode for the builtin template.
<b>Step 4</b>	<b>switchport access vlan <i>vlan-id</i></b> <b>Example:</b> Device(config-template)# switchport access vlan 20	Sets the VLAN when the interface is in access mode.
<b>Step 5</b>	<b>description <i>description</i></b> <b>Example:</b> Device(config-template)# description modifiedAP	Modifies the description of the built-in template.

	Command or Action	Purpose
<b>Step 6</b>	<b>exit</b> <b>Example:</b> Device(config-template)# exit	Exits template configuration mode and enters global configuration mode.
<b>Step 7</b>	<b>autoconf enable</b> <b>Example:</b> Device(config)# autoconf enable	Enables the Autoconf feature.
<b>Step 8</b>	<b>end</b> <b>Example:</b> Device(config)# end	Exits global configuration mode and enters privileged EXEC mode.
<b>Step 9</b>	<b>show template interface binding all</b> <b>Example:</b> Device# show template interface binding all	Displays whether the template is applied on the interface.

### Verifying the Device classification of an End Device

#### Verifying the Interface Template on an Interface

The following example shows that the IP camera and access points are classified by the Device Classifier with correct attributes:

```
Device# show device classifier attached detail
```

```
DC default profile file version supported = 1
```

```
Detail:
```

MAC_Address	Port_Id	Cert	Parent	Proto	ProfileType	Profile Name
001d.a1ef.23a8	Gi1/0/7	30	3	C	M	Cisco-AIR-AP-1130
AIR-AP1131AG-A-K9						cisco
001e.7a26.eb05	Gi1/0/30	70	2	C	M	Cisco-IP-Camera
IP Camera						Cisco

The following example shows that a built-in interface template is applied on the interface:

```
Device# show template interface binding all
```

Template-Name	Source	Method	Interface
IP_CAMERA_INTERFACE_TEMPLATE	Built-in	dynamic	Gi1/0/30
AP_INTERFACE_TEMPLATE	Modified-Built-in	dynamic	Gi1/0/7



## Migrating from ASP to Autoconf

### Before you begin

Verify that the AutoSmart Port (ASP) macro is running using the **show running-config | include macro auto global** command.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"><li>• Enter your password if prompted.</li></ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>no macro auto global processing</b> <b>Example:</b> Device(config)# no macro auto global processing	Disables ASP on a global level.
<b>Step 4</b>	<b>exit</b> <b>Example:</b> Device(config)# exit	Exits global configuration mode and returns to privileged EXEC mode.
<b>Step 5</b>	<b>clear macro auto configuration all</b> <b>Example:</b> Device# clear macro auto configuration all	Clears macro configurations for all interfaces.
<b>Step 6</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 7</b>	<b>autoconf enable</b> <b>Example:</b> Device(config)# autoconf enable	Enables the Autoconf feature.
<b>Step 8</b>	<b>end</b> <b>Example:</b> Device(config)# end	Exits global configuration mode and returns to privileged EXEC mode.

# Configuration Examples for Autoconf

## Example: Applying a Built-in Template to an End Device

The following example shows how to apply a built-in template to an end device connected to an interface.

```
Device> enable
Device(config)# configure terminal
Device(config)# autoconf enable
Device(config)# end
Device# show device classifier attached interface Gi3/0/26
Device# show template binding target GigabitEthernet 3/0/26
```

## Example: Applying a Modified Built-in Template to an End Device

The following example shows how to modified built-in template and verify the configuration:

```
Device> enable
Device(config)# configure terminal
Device(config)# template AP_INTERFACE_TEMPLATE
Device(config-template)# switchport access vlan 20
Device(config-template)# description modifiedAP
Device(config-template)# exit
Device(config)# autoconf enable
Device(config)# end
Device# show template interface binding all
```

## Example: Migrating from ASP Macros to Autoconf

The following example shows how to migrate from ASP to Autoconf:

```
Device> enable
Device# configure terminal
Device(config)# no macro auto global processing
Device(config)# exit
Device# clear macro auto configuration all
Device# configure terminal
Device(config)# autoconf enable
Device(config)# end
```

# Additional References for Autoconf

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Command List, All Releases</a>

Related Topic	Document Title
Cisco identity-based networking services commands	<a href="#">Cisco IOS Identity-Based Networking Services Command Reference</a>
Interface Templates	“Interface Templates” module in <a href="#">Identity-Based Networking Services Configuration Guide</a> .

### Standards and RFCs

Standard/RFC	Title
IEEE 802.1X	<i>Port Based Network Access Control</i>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

## Feature Information for Autoconf

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

Table 67: Feature Information for Autoconf

Feature Name	Releases	Feature Information
Autoconf	Cisco IOS XE Denali 16.3.1	<p>Autoconf is a solution that can be used to manage port configurations for data or voice VLANs, quality of QoS parameters, storm control, and MAC-based port security on end devices that are deployed in the access layer of a network.</p> <p>The Autoconf feature automatically applies the configurations needed on the device ports to enable the efficient performance of each directly connected end device using a set of interface configurations that are configured inside an interface template. This mechanism ensures that no configurations are needed from the end device.</p> <p>The following commands were added or modified: <b>autoconf enable</b>, <b>map attribute-to-service (autoconf)</b>, <b>map device-type (service-template)</b>, <b>parameter-map type subscriber (service-template)</b>, <b>show parameter-map type subscriber attribute-to-service all</b>, <b>show template interface</b>.</p>



## CHAPTER 69

# Configuring Cisco IOS Configuration Engine

- [Prerequisites for Configuring the Configuration Engine, on page 1015](#)
- [Restrictions for Configuring the Configuration Engine, on page 1015](#)
- [Information About Configuring the Configuration Engine, on page 1016](#)
- [How to Configure the Configuration Engine, on page 1021](#)
- [Monitoring CNS Configurations, on page 1032](#)
- [Additional References, on page 1033](#)

## Prerequisites for Configuring the Configuration Engine

- Obtain the name of the configuration engine instance to which you are connecting.
- Because the CNS uses both the event bus and the configuration server to provide configurations to devices, you must define both ConfigID and Device ID for each configured device.
- All devices configured with the **cns config partial** global configuration command must access the event bus. The DeviceID, as originated on the device, must match the DeviceID of the corresponding device definition in the Cisco Configuration Engine. You must know the hostname of the event bus to which you are connecting.

## Restrictions for Configuring the Configuration Engine

- Within the scope of a single instance of the configuration server, no two configured devices can share the same value for ConfigID.
- Within the scope of a single instance of the event bus, no two configured devices can share the same value for DeviceID.

# Information About Configuring the Configuration Engine

## Cisco Configuration Engine Software

The Cisco Configuration Engine is network management utility software that acts as a configuration service for automating the deployment and management of network devices and services. Each Cisco Configuration Engine manages a group of Cisco devices (devices and routers) and the services that they deliver, storing their configurations and delivering them as needed. The Cisco Configuration Engine automates initial configurations and configuration updates by generating device-specific configuration changes, sending them to the device, executing the configuration change, and logging the results.

The Cisco Configuration Engine supports standalone and server modes and has these Cisco Networking Services (CNS) components:

- Configuration service:
  - Web server
  - File manager
  - Namespace mapping server
- Event service (event gateway)
- Data service directory (data models and schema)



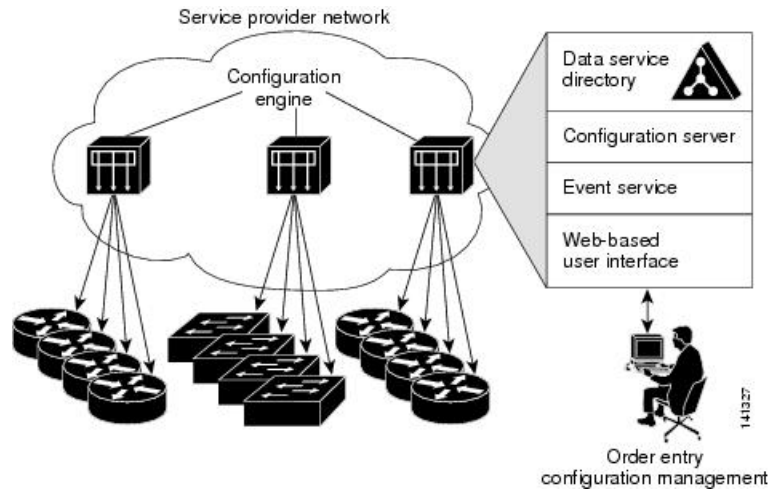
---

**Note** Support for Cisco Configuration Engine will be deprecated in future releases. Use the configuration described in [Cisco Plug and Play Feature Guide](#).

---

In standalone mode, the Cisco Configuration Engine supports an embedded directory service. In this mode, no external directory or other data store is required. In server mode, the Cisco Configuration Engine supports the use of a user-defined external directory.

**Figure 78: Cisco Configuration Engine Architectural Overview**



## Configuration Service

The Configuration Service is the core component of the Cisco Configuration Engine. It consists of a Configuration Server that works with Cisco IOS CNS agents on the device. The Configuration Service delivers device and service configurations to the device for initial configuration and mass reconfiguration by logical groups. Devices receive their initial configuration from the Configuration Service when they start up on the network for the first time.

The Configuration Service uses the CNS Event Service to send and receive configuration change events and to send success and failure notifications.

The Configuration Server is a web server that uses configuration templates and the device-specific configuration information stored in the embedded (standalone mode) or remote (server mode) directory.

Configuration templates are text files containing static configuration information in the form of CLI commands. In the templates, variables are specified by using Lightweight Directory Access Protocol (LDAP) URLs that reference the device-specific configuration information stored in a directory.

The Cisco IOS agent can perform a syntax check on received configuration files and publish events to show the success or failure of the syntax check. The configuration agent can either apply configurations immediately or delay the application until receipt of a synchronization event from the configuration server.

## Event Service

The Cisco Configuration Engine uses the Event Service for receipt and generation of configuration events. The Event Service consists of an event agent and an event gateway. The event agent is on the device and facilitates the communication between the device and the event gateway on the Cisco Configuration Engine.

The Event Service is a highly capable publish-and-subscribe communication method. The Event Service uses subject-based addressing to send messages to their destinations. Subject-based addressing conventions define a simple, uniform namespace for messages and their destinations.

## NameSpace Mapper

The Cisco Configuration Engine includes the NameSpace Mapper (NSM) that provides a lookup service for managing logical groups of devices based on application, device or group ID, and event.

Cisco IOS devices recognize only event subject-names that match those configured in Cisco IOS software; for example, `cisco.cns.config.load`. You can use the namespace mapping service to designate events by using any desired naming convention. When you have populated your data store with your subject names, NSM changes your event subject-name strings to those known by Cisco IOS.

For a subscriber, when given a unique device ID and event, the namespace mapping service returns a set of events to which to subscribe. Similarly, for a publisher, when given a unique group ID, device ID, and event, the mapping service returns a set of events on which to publish.

## Cisco Networking Services IDs and Device Hostnames

The Cisco Configuration Engine assumes that a unique identifier is associated with each configured device. This unique identifier can take on multiple synonyms, where each synonym is unique within a particular namespace. The event service uses namespace content for subject-based addressing of messages.

The Cisco Configuration Engine intersects two namespaces, one for the event bus and the other for the configuration server. Within the scope of the configuration server namespace, the term *ConfigID* is the unique identifier for a device. Within the scope of the event bus namespace, the term *DeviceID* is the CNS unique identifier for a device.

### ConfigID

Each configured device has a unique ConfigID, which serves as the key into the Cisco Configuration Engine directory for the corresponding set of device CLI attributes. The ConfigID defined on the device must match the ConfigID for the corresponding device definition on the Cisco Configuration Engine.

The ConfigID is fixed at startup time and cannot be changed until the device restarts, even if the device hostname is reconfigured.

### DeviceID

Each configured device participating on the event bus has a unique DeviceID, which is analogous to the device source address so that the device can be targeted as a specific destination on the bus.

The origin of the DeviceID is defined by the Cisco IOS hostname of the device. However, the DeviceID variable and its usage reside within the event gateway adjacent to the device.

The logical Cisco IOS termination point on the event bus is embedded in the event gateway, which in turn functions as a proxy on behalf of the device. The event gateway represents the device and its corresponding DeviceID to the event bus.

The device declares its hostname to the event gateway immediately after the successful connection to the event gateway. The event gateway couples the DeviceID value to the Cisco IOS hostname each time this connection is established. The event gateway retains this DeviceID value for the duration of its connection to the device.



## Hostname and DeviceID

The DeviceID is fixed at the time of the connection to the event gateway and does not change even when the device hostname is reconfigured.

When changing the device hostname on the device, the only way to refresh the DeviceID is to break the connection between the device and the event gateway. For instructions on refreshing DeviceIDs, see "Related Topics."

When the connection is reestablished, the device sends its modified hostname to the event gateway. The event gateway redefines the DeviceID to the new value.

**Caution**

When using the Cisco Configuration Engine user interface, you must first set the DeviceID field to the hostname value that the device acquires *after*, not *before*, and you must reinitialize the configuration for your Cisco IOS CNS agent. Otherwise, subsequent partial configuration command operations may malfunction.

## Hostname, DeviceID, and ConfigID

In standalone mode, when a hostname value is set for a device, the configuration server uses the hostname as the DeviceID when an event is sent on hostname. If the hostname has not been set, the event is sent on the `cn=<value>` of the device.

In server mode, the hostname is not used. In this mode, the unique DeviceID attribute is always used for sending an event on the bus. If this attribute is not set, you cannot update the device.

These and other associated attributes (tag value pairs) are set when you run **Setup** on the Cisco Configuration Engine.

## Cisco IOS CNS Agents

The CNS event agent feature allows the device to publish and subscribe to events on the event bus and works with the Cisco IOS CNS agent. These agents, embedded in the device Cisco IOS software, allow the device to be connected and automatically configured.

## Initial Configuration

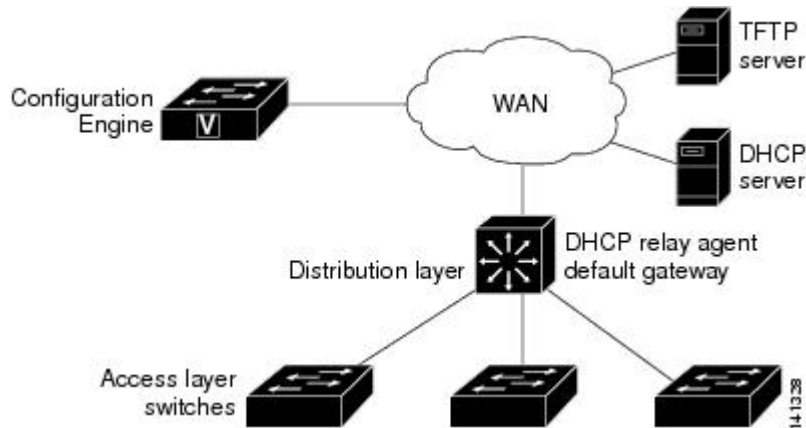
When the device first comes up, it attempts to get an IP address by broadcasting a Dynamic Host Configuration Protocol (DHCP) request on the network. Assuming there is no DHCP server on the subnet, the distribution device acts as a DHCP relay agent and forwards the request to the DHCP server. Upon receiving the request, the DHCP server assigns an IP address to the new device and includes the Trivial File Transfer Protocol (TFTP) server Internet Protocol (IP) address, the path to the bootstrap configuration file, and the default gateway IP address in a unicast reply to the DHCP relay agent. The DHCP relay agent forwards the reply to the device.

The device automatically configures the assigned IP address on interface VLAN 1 (the default) and downloads the bootstrap configuration file from the TFTP server. Upon successful download of the bootstrap configuration file, the device loads the file in its running configuration.

The Cisco IOS CNS agents initiate communication with the Configuration Engine by using the appropriate ConfigID and EventID. The Configuration Engine maps the Config ID to a template and downloads the full configuration file to the device.

The following figure shows a sample network configuration for retrieving the initial bootstrap configuration file by using DHCP-based autoconfiguration.

Figure 79: Initial Configuration



## Incremental (Partial) Configuration

After the network is running, new services can be added by using the Cisco IOS CNS agent. Incremental (partial) configurations can be sent to the device. The actual configuration can be sent as an event payload by way of the event gateway (push operation) or as a signal event that triggers the device to initiate a pull operation.

The device can check the syntax of the configuration before applying it. If the syntax is correct, the device applies the incremental configuration and publishes an event that signals success to the configuration server. If the device does not apply the incremental configuration, it publishes an event showing an error status. When the device has applied the incremental configuration, it can write it to nonvolatile random-access memory (NVRAM) or wait until signaled to do so.

## Synchronized Configuration

When the device receives a configuration, it can defer application of the configuration upon receipt of a write-signal event. The write-signal event tells the device not to save the updated configuration into its NVRAM. The device uses the updated configuration as its running configuration. This ensures that the device configuration is synchronized with other network activities before saving the configuration in NVRAM for use at the next reboot.

## Automated CNS Configuration

To enable automated CNS configuration of the device, you must first complete the prerequisites listed in this topic. When you complete them, power on the device. At the **setup** prompt, do nothing; the device begins the initial configuration. When the full configuration file is loaded on your device, you do not need to do anything else.

For more information on what happens during initial configuration, see "Related Topics."

Table 68: Prerequisites for Enabling Automatic Configuration

Device	Required Configuration
Access device	Factory default (no configuration file)

Device	Required Configuration
Distribution device	<ul style="list-style-type: none"> <li>• IP helper address</li> <li>• Enable DHCP relay agent<sup>2</sup></li> <li>• IP routing (if used as default gateway)</li> </ul>
DHCP server	<ul style="list-style-type: none"> <li>• IP address assignment</li> <li>• TFTP server IP address</li> <li>• Path to bootstrap configuration file on the TFTP server</li> <li>• Default gateway IP address</li> </ul>
TFTP server	<ul style="list-style-type: none"> <li>• A bootstrap configuration file that includes the CNS configuration commands that enable the device to communicate with the Configuration Engine</li> <li>• The device configured to use either the device MAC address or the serial number (instead of the default hostname) to generate the ConfigID and EventID</li> <li>• The CNS event agent configured to push the configuration file to the device</li> </ul>
CNS Configuration Engine	One or more templates for each type of device, with the ConfigID of the device mapped to the template.

<sup>2</sup> A DHCP Relay is needed only when the DHCP Server is on a different subnet from the client.

## How to Configure the Configuration Engine

### Enabling the CNS Event Agent



**Note** You must enable the CNS event agent on the device before you enable the CNS configuration agent.

Follow these steps to enable the CNS event agent on the device.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
Step 2	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
Step 3	<p><b>cns event</b> {<i>hostname   ip-address</i>} [<i>port-number</i>] [ <b>keepalive</b> <i>seconds</i> <i>retry-count</i>] [ <b>failover-time</b> <i>seconds</i> ] [ <b>reconnect-time</b> <i>time</i> ]   <b>backup</b>]</p> <p><b>Example:</b></p> <pre>Device(config)# cns event 10.180.1.27 keepalive 120 10</pre>	<p>Enables the event agent, and enters the gateway parameters.</p> <ul style="list-style-type: none"> <li>• For {<i>hostname   ip-address</i>}, enter either the hostname or the IP address of the event gateway.</li> <li>• (Optional) For <i>port number</i>, enter the port number for the event gateway. The default port number is 11011.</li> <li>• (Optional) For <b>keepalive</b> <i>seconds</i>, enter how often the device sends keepalive messages. For <i>retry-count</i>, enter the number of unanswered keepalive messages that the device sends before the connection is terminated. The default for each is 0.</li> <li>• (Optional) For <b>failover-time</b> <i>seconds</i>, enter how long the device waits for the primary gateway route after the route to the backup gateway is established.</li> <li>• (Optional) For <b>reconnect-time</b> <i>time</i>, enter the maximum time interval that the device waits before trying to reconnect to the event gateway.</li> <li>• (Optional) Enter <b>backup</b> to show that this is the backup gateway. (If omitted, this is the primary gateway.)</li> </ul> <p><b>Note</b> Though visible in the command-line help string, the <b>encrypt</b> and the <b>clock-timeout</b> <i>time</i> keywords are not supported.</p>
Step 4	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
Step 5	<p><b>show running-config</b></p> <p><b>Example:</b></p>	Verifies your entries.

	Command or Action	Purpose
	Device# <code>show running-config</code>	
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

**What to do next**

To verify information about the event agent, use the **show cns event connections** command in privileged EXEC mode.

To disable the CNS event agent, use the **no cns event { ip-address | hostname }** global configuration command.

## Enabling the Cisco IOS CNS Agent

Follow these steps to enable the Cisco IOS CNS agent on the device.

**Before you begin**

You must enable the CNS event agent on the device before you enable this agent.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>cns config initial {hostname   ip-address} [port-number]</b> <b>Example:</b> Device(config)# <code>cns config initial 10.180.1.27 10</code>	Enables the Cisco IOS CNS agent, and enters the configuration server parameters. <ul style="list-style-type: none"> <li>• For <i>{hostname   ip-address}</i>, enter either the hostname or the IP address of the configuration server.</li> <li>• (Optional) For <i>port number</i>, enter the port number for the configuration server.</li> </ul>

	Command or Action	Purpose
		This command enables the Cisco IOS CNS agent and initiates an initial configuration on the device.
<b>Step 4</b>	<b>cns config partial</b> { <i>hostname</i>   <i>ip-address</i> } [ <i>port-number</i> ]  <b>Example:</b>  Device(config)# <b>cns config partial</b> <b>10.180.1.27 10</b>	Enables the Cisco IOS CNS agent, and enters the configuration server parameters. <ul style="list-style-type: none"> <li>• For {<i>hostname</i>   <i>ip-address</i>}, enter either the hostname or the IP address of the configuration server.</li> <li>• (Optional) For <i>port number</i>, enter the port number for the configuration server.</li> </ul> Enables the Cisco IOS CNS agent and initiates a partial configuration on the device.
<b>Step 5</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b>  <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.
<b>Step 8</b>	Start the Cisco IOS CNS agent on the device.	

### What to do next

You can now use the Cisco Configuration Engine to remotely send incremental configurations to the device.

## Enabling an Initial Configuration for Cisco IOS CNS Agent

Follow these steps to enable the CNS configuration agent and initiate an initial configuration on the device.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>	Enables privileged EXEC mode.

	Command or Action	Purpose
	<b>Example:</b>  Device> <b>enable</b>	<ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>cns template connect <i>name</i></b>  <b>Example:</b>  Device (config)# <b>cns template connect template-dhcp</b>	Enters CNS template connect configuration mode, and specifies the name of the CNS connect template.
<b>Step 4</b>	<b>cli <i>config-text</i></b>  <b>Example:</b>  Device (config-tmpl-conn)# <b>cli ip address dhcp</b>	Enters a command line for the CNS connect template. Repeat this step for each command line in the template.
<b>Step 5</b>	Repeat Steps 3 to 4 to configure another CNS connect template.	
<b>Step 6</b>	<b>exit</b>  <b>Example:</b>  Device (config)# <b>exit</b>	Returns to global configuration mode.
<b>Step 7</b>	<b>cns connect <i>name</i> [<i>retries number</i>] [<i>retry-interval seconds</i>] [<i>sleep seconds</i>] [<i>timeout seconds</i>]</b>  <b>Example:</b>  Device (config)# <b>cns connect dhcp</b>	Enters CNS connect configuration mode, specifies the name of the CNS connect profile, and defines the profile parameters. The device uses the CNS connect profile to connect to the Configuration Engine. <ul style="list-style-type: none"> <li>• Enter the <i>name</i> of the CNS connect profile.</li> <li>• (Optional) For <b>retries number</b>, enter the number of connection retries. The range is 1 to 30. The default is 3.</li> <li>• (Optional) For <b>retry-interval seconds</b>, enter the interval between successive connection attempts to the Configuration Engine. The range is 1 to 40 seconds. The default is 10 seconds.</li> <li>• (Optional) For <b>sleep seconds</b>, enter the amount of time before which the first</li> </ul>

	Command or Action	Purpose
		<p>connection attempt occurs. The range is 0 to 250 seconds. The default is 0.</p> <ul style="list-style-type: none"> <li>• (Optional) For <b>timeout seconds</b>, enter the amount of time after which the connection attempts end. The range is 10 to 2000 seconds. The default is 120.</li> </ul>
<b>Step 8</b>	<p><b>discover</b> {<b>controller</b> <i>controller-type</i>   <b>dlci</b> [<b>subinterface</b> <i>subinterface-number</i>]   <b>interface</b> [<i>interface-type</i>]   <b>line</b> <i>line-type</i>}</p> <p><b>Example:</b></p> <pre>Device(config-cns-conn) # discover interface gigabitethernet</pre>	<p>Specifies the interface parameters in the CNS connect profile.</p> <ul style="list-style-type: none"> <li>• For <b>controller</b> <i>controller-type</i>, enter the controller type.</li> <li>• For <b>dlci</b>, enter the active data-link connection identifiers (DLCIs).</li> </ul> <p>(Optional) For <b>subinterface</b> <i>subinterface-number</i>, specify the point-to-point subinterface number that is used to search for active DLCIs.</p> <ul style="list-style-type: none"> <li>• For <b>interface</b> [<i>interface-type</i>], enter the type of interface.</li> <li>• For <b>line</b> <i>line-type</i>, enter the line type.</li> </ul>
<b>Step 9</b>	<p><b>template</b> <i>name</i> [... <i>name</i>]</p> <p><b>Example:</b></p> <pre>Device(config-cns-conn) # template template-dhcp</pre>	<p>Specifies the list of CNS connect templates in the CNS connect profile to be applied to the device configuration. You can specify more than one template.</p>
<b>Step 10</b>	<p>Repeat Steps 8 to 9 to specify more interface parameters and CNS connect templates in the CNS connect profile.</p>	
<b>Step 11</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-cns-conn) # exit</pre>	<p>Returns to global configuration mode.</p>
<b>Step 12</b>	<p><b>hostname</b> <i>name</i></p> <p><b>Example:</b></p> <pre>Device(config) # hostname device1</pre>	<p>Enters the hostname for the device.</p>
<b>Step 13</b>	<p><b>ip route</b> <i>network-number</i></p> <p><b>Example:</b></p> <pre>RemoteDevice(config) # ip route</pre>	<p>(Optional) Establishes a static route to the Configuration Engine whose IP address is <i>network-number</i>.</p>



	Command or Action	Purpose
	172.28.129.22 255.255.255.255 11.11.11.1	
<b>Step 14</b>	<p><b>cns id</b> <i>interface num</i> {<b>dns-reverse</b>   <b>ipaddress</b>   <b>mac-address</b>} [<b>event</b>] [<b>image</b>]</p> <p><b>Example:</b></p> <pre>RemoteDevice(config)# <b>cns id</b> GigabitEthernet0/1 <b>ipaddress</b></pre>	<p>(Optional) Sets the unique EventID or ConfigID used by the Configuration Engine. If you enter this command, do not enter the <b>cns id</b> {<b>hardware-serial</b>   <b>hostname</b>   <b>string string</b>   <b>udi</b>} [<b>event</b>] [<b>image</b>] command.</p> <ul style="list-style-type: none"> <li>For <i>interface num</i>, enter the type of interface. For example, ethernet, group-async, loopback, or virtual-template. This setting specifies from which interface the IP or MAC address should be retrieved to define the unique ID.</li> <li>For {<b>dns-reverse</b>   <b>ipaddress</b>   <b>mac-address</b>}, enter <b>dns-reverse</b> to retrieve the hostname and assign it as the unique ID, enter <b>ipaddress</b> to use the IP address, or enter <b>mac-address</b> to use the MAC address as the unique ID.</li> <li>(Optional) Enter <b>event</b> to set the ID to be the event-id value used to identify the device.</li> <li>(Optional) Enter <b>image</b> to set the ID to be the image-id value used to identify the device.</li> </ul> <p><b>Note</b> If both the <b>event</b> and <b>image</b> keywords are omitted, the image-id value is used to identify the device.</p>
<b>Step 15</b>	<p><b>cns id</b> {<b>hardware-serial</b>   <b>hostname</b>   <b>string string</b>   <b>udi</b>} [<b>event</b>] [<b>image</b>]</p> <p><b>Example:</b></p> <pre>RemoteDevice(config)# <b>cns id</b> <b>hostname</b></pre>	<p>(Optional) Sets the unique EventID or ConfigID used by the Configuration Engine. If you enter this command, do not enter the <b>cns id</b> <i>interface num</i> {<b>dns-reverse</b>   <b>ipaddress</b>   <b>mac-address</b>} [<b>event</b>] [<b>image</b>] command.</p> <ul style="list-style-type: none"> <li>For { <b>hardware-serial</b>   <b>hostname</b>   <b>string string</b>   <b>udi</b> }, enter <b>hardware-serial</b> to set the device serial number as the unique ID, enter <b>hostname</b> (the default) to select the device hostname as the unique ID, enter an arbitrary text string for <b>string string</b> as the unique ID, or enter <b>udi</b> to set the unique device identifier (UDI) as the unique ID.</li> </ul>

	Command or Action	Purpose
<b>Step 16</b>	<p><b>cns config initial</b> {<i>hostname</i>   <i>ip-address</i>} [<i>port-number</i>] [<i>event</i>] [<b>no-persist</b>] [<b>page</b> <i>page</i>] [<b>source</b> <i>ip-address</i>] [<b>syntax-check</b>]</p> <p><b>Example:</b></p> <pre>RemoteDevice(config)# <b>cns config initial</b> 10.1.1.1 <b>no-persist</b></pre>	<p>Enables the Cisco IOS agent, and initiates an initial configuration.</p> <ul style="list-style-type: none"> <li>For {<i>hostname</i>   <i>ip-address</i>}, enter the hostname or the IP address of the configuration server.</li> <li>(Optional) For <i>port-number</i>, enter the port number of the configuration server. The default port number is 80.</li> <li>(Optional) Enable <b>event</b> for configuration success, failure, or warning messages when the configuration is finished.</li> <li>(Optional) Enable <b>no-persist</b> to suppress the automatic writing to NVRAM of the configuration pulled as a result of entering the <b>cns config initial</b> global configuration command. If the <b>no-persist</b> keyword is not entered, using the <b>cns config initial</b> command causes the resultant configuration to be automatically written to NVRAM.</li> <li>(Optional) For <b>page</b> <i>page</i>, enter the web page of the initial configuration. The default is /Config/config/asp.</li> <li>(Optional) Enter <b>source</b> <i>ip-address</i> to use for source IP address.</li> <li>(Optional) Enable <b>syntax-check</b> to check the syntax when this parameter is entered.</li> </ul> <p><b>Note</b> Though visible in the command-line help string, the <b>encrypt</b>, <b>status url</b>, and <b>inventory</b> keywords are not supported.</p>
<b>Step 17</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# <b>end</b></pre>	Returns to privileged EXEC mode.
<b>Step 18</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# <b>show running-config</b></pre>	Verifies your entries.

	Command or Action	Purpose
<b>Step 19</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

### What to do next

To verify information about the configuration agent, use the **show cns config connections** command in privileged EXEC mode.

To disable the CNS Cisco IOS agent, use the **no cns config initial** { *ip-address* | *hostname* } global configuration command.

## Refreshing DeviceIDs

Follow these steps to refresh a DeviceID when changing the hostname on the device.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>show cns config connections</b> <b>Example:</b> <pre>Device# show cns config connections</pre>	Displays whether the CNS event agent is connecting to the gateway, connected, or active, and the gateway used by the event agent, its IP address and port number.
<b>Step 3</b>	Make sure that the CNS event agent is properly connected to the event gateway.	Examine the output of <b>show cns config connections</b> for the following: <ul style="list-style-type: none"> <li>• Connection is active.</li> <li>• Connection is using the currently configured device hostname. The DeviceID will be refreshed to correspond to the new hostname configuration using these instructions.</li> </ul>
<b>Step 4</b>	<b>show cns event connections</b> <b>Example:</b> <pre>Device# show cns event connections</pre>	Displays the event connection information for your device.

	Command or Action	Purpose
<b>Step 5</b>	Record from the output of Step 4 the information for the currently connected connection listed below. You will be using the IP address and port number in subsequent steps of these instructions.	
<b>Step 6</b>	<b>configure terminal</b> <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 7</b>	<b>no cns event ip-address port-number</b> <b>Example:</b>  Device(config)# <code>no cns event 172.28.129.22 2012</code>	Specifies the IP address and port number that you recorded in Step 5 in this command.  This command breaks the connection between the device and the event gateway. It is necessary to first break, then reestablish, this connection to refresh the DeviceID.
<b>Step 8</b>	<b>cns event ip-address port-number</b> <b>Example:</b>  Device(config)# <code>cns event 172.28.129.22 2012</code>	Specifies the IP address and port number that you recorded in Step 5 in this command.  This command reestablishes the connection between the device and the event gateway.
<b>Step 9</b>	<b>end</b> <b>Example:</b>  Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 10</b>	Make sure that you have reestablished the connection between the device and the event connection by examining the output from <b>show cns event connections</b> .	
<b>Step 11</b>	<b>show running-config</b> <b>Example:</b>  Device# <code>show running-config</code>	Verifies your entries.
<b>Step 12</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Enabling a Partial Configuration for Cisco IOS CNS Agent

Follow these steps to enable the Cisco IOS CNS agent and to initiate a partial configuration on the device.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>cns config partial</b> <i>{ip-address   hostname}</i> <i>[port-number] [source ip-address]</i> <b>Example:</b> Device(config)# <b>cns config partial</b> 172.28.129.22 2013	Enables the configuration agent, and initiates a partial configuration. <ul style="list-style-type: none"> <li>• For <i>{ip-address   hostname}</i>, enter the IP address or the hostname of the configuration server.</li> <li>• (Optional) For <i>port-number</i>, enter the port number of the configuration server. The default port number is 80.</li> <li>• (Optional) Enter <b>source ip-address</b> to use for the source IP address.</li> </ul> <p><b>Note</b> Though visible in the command-line help string, the <b>encrypt</b> keyword is not supported.</p>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Device# <code>copy running-config startup-config</code>	

### What to do next

To verify information about the configuration agent, use either the **show cns config stats** or the **show cns config outstanding** command in privileged EXEC mode.

To disable the Cisco IOS agent, use the **no cns config partial** { *ip-address* | *hostname* } global configuration command. To cancel a partial configuration, use the **cns config cancel** global configuration command.

## Monitoring CNS Configurations

Table 69: CNS show Commands

Command	Purpose
<b>show cns config connections</b>  Device# <code>show cns config connections</code>	Displays the status of the CNS Cisco IOS CNS agent connections.
<b>show cns config outstanding</b>  Device# <code>show cns config outstanding</code>	Displays information about incremental (partial) CNS configurations that have started but are not yet completed.
<b>show cns config stats</b>  Device# <code>show cns config stats</code>	Displays statistics about the Cisco IOS CNS agent.
<b>show cns event connections</b>  Device# <code>show cns event connections</code>	Displays the status of the CNS event agent connections.
<b>show cns event gateway</b>  Device# <code>show cns event gateway</code>	Displays the event gateway information for your device.
<b>show cns event stats</b>  Device# <code>show cns event stats</code>	Displays statistics about the CNS event agent.
<b>show cns event subject</b>  Device# <code>show cns event subject</code>	Displays a list of event agent subjects that are subscribed to by applications.

# Additional References

## Related Documents

Related Topic	Document Title
Configuration Engine Setup	<p><i>Cisco Configuration Engine Installation and Setup Guide, 1.5 for Linux</i></p> <p><a href="https://www.cisco.com/en/US/docs/net_mgmt/configuration_engine/1.5/installation_linux/guide/setup_1.html">https://www.cisco.com/en/US/docs/net_mgmt/configuration_engine/1.5/installation_linux/guide/setup_1.html</a></p>

## Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

## Standards and RFCs

Standard/RFC	Title
None	-

## MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

## Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>







# CHAPTER 70

## Configuring the Cisco Discovery Protocol

Cisco Discovery Protocol is a Layer 2, media-independent, and network-independent protocol that runs on Cisco devices and enables networking applications to learn about directly connected devices nearby. This protocol facilitates the management of Cisco devices by discovering these devices, determining how they are configured, and allowing systems using different network-layer protocols to learn about each other.

This module describes Cisco Discovery Protocol Version 2 and how it functions with SNMP.

- [Information About CDP, on page 1035](#)
- [How to Configure CDP, on page 1036](#)
- [Monitoring and Maintaining Cisco Discovery Protocol, on page 1042](#)
- [Additional References, on page 1043](#)

## Information About CDP

### Cisco Discovery Protocol Overview

Cisco Discovery Protocol is a device discovery protocol that runs over Layer 2 (the data-link layer) on all Cisco-manufactured devices (routers, bridges, access servers, controllers, and switches) and allows network management applications to discover Cisco devices that are neighbors of already known devices. With Cisco Discovery Protocol, network management applications can learn the device type and the SNMP agent address of neighboring devices running lower-layer, transparent protocols. This feature enables applications to send SNMP queries to neighboring devices.

Cisco Discovery Protocol runs on all media that support Subnetwork Access Protocol (SNAP). Because Cisco Discovery Protocol runs over the data-link layer only, two systems that support different network-layer protocols can learn about each other.

Each Cisco Discovery Protocol-configured device sends periodic messages to a multicast address, advertising at least one address at which it can receive SNMP messages. The advertisements also contain time-to-live, or holdtime information, which is the length of time a receiving device holds Cisco Discovery Protocol information before discarding it. Each device also listens to the messages sent by other devices to learn about neighboring devices.

On the device, Cisco Discovery Protocol enables Network Assistant to display a graphical view of the network. The device uses Cisco Discovery Protocol to find cluster candidates and maintain information about cluster members and other devices up to three cluster-enabled devices away from the command device by default.

- Cisco Discovery Protocol identifies connected endpoints that communicate directly with the device.

- To prevent duplicate reports of neighboring devices, only one wired device reports the location information.
- The wired device and the endpoints both send and receive location information.

## Default Cisco Discovery Protocol Configuration

This table shows the default Cisco Discovery Protocol configuration.

Feature	Default Setting
Cisco Discovery Protocol global state	Enabled
Cisco Discovery Protocol interface state	Enabled
Cisco Discovery Protocol timer (packet update frequency)	60 seconds
Cisco Discovery Protocol holdtime (before discarding)	180 seconds
Cisco Discovery Protocol Version-2 advertisements	Enabled

## How to Configure CDP

### Configuring Cisco Discovery Protocol Characteristics

You can configure these Cisco Discovery Protocol characteristics:

- Frequency of Cisco Discovery Protocol updates
- Amount of time to hold the information before discarding it
- Whether or not to send Version 2 advertisements



**Note** Steps 3 through 5 are all optional and can be performed in any order.

Follow these steps to configure the Cisco Discovery Protocol characteristics.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 3</b>	<b>cdp timer</b> <i>seconds</i> <b>Example:</b> Device(config)# <code>cdp timer 20</code>	(Optional) Sets the transmission frequency of Cisco Discovery Protocol updates in seconds. The range is 5 to 254; the default is 60 seconds.
<b>Step 4</b>	<b>cdp holdtime</b> <i>seconds</i> <b>Example:</b> Device(config)# <code>cdp holdtime 60</code>	(Optional) Specifies the amount of time a receiving device should hold the information sent by your device before discarding it. The range is 10 to 255 seconds; the default is 180 seconds.
<b>Step 5</b>	<b>cdp advertise-v2</b> <b>Example:</b> Device(config)# <code>cdp advertise-v2</code>	(Optional) Configures Cisco Discovery Protocol to send Version 2 advertisements. This is the default state.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show running-config</b> <b>Example:</b> Device# <code>show running-config</code>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

**What to do next**

Use the **no** form of the Cisco Discovery Protocol commands to return to the default settings.

## Disabling Cisco Discovery Protocol

Cisco Discovery Protocol is enabled by default.



**Note** Device clusters and other Cisco devices (such as Cisco IP Phones) regularly exchange Cisco Discovery Protocol messages. Disabling Cisco Discovery Protocol can interrupt cluster discovery and device connectivity.

Follow these steps to disable the Cisco Discovery Protocol device discovery capability.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>no cdp run</b> <b>Example:</b> Device(config)# <b>no cdp run</b>	Disables Cisco Discovery Protocol.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

### What to do next

You must reenable Cisco Discovery Protocol to use it.

## Enabling Cisco Discovery Protocol

Cisco Discovery Protocol is enabled by default.



**Note** Device clusters and other Cisco devices (such as Cisco IP Phones) regularly exchange Cisco Discovery Protocol messages. Disabling Cisco Discovery Protocol can interrupt cluster discovery and device connectivity.

Follow these steps to enable Cisco Discovery Protocol when it has been disabled.

### Before you begin

Cisco Discovery Protocol must be disabled, or it cannot be enabled.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>cdp run</b> <b>Example:</b>  Device(config)# <b>cdp run</b>	Enables Cisco Discovery Protocol if it has been disabled.
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config</b>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	<code>startup-config</code>	

### What to do next

Use the **show run all** command to show that Cisco Discovery Protocol has been enabled. If you enter only **show run**, the enabling of Cisco Discovery Protocol may not be displayed.

## Disabling Cisco Discovery Protocol on an Interface

Cisco Discovery Protocol is enabled by default on all supported interfaces to send and to receive Cisco Discovery Protocol information.



**Note** Device clusters and other Cisco devices (such as Cisco IP Phones) regularly exchange Cisco Discovery Protocol messages. Disabling Cisco Discovery Protocol can interrupt cluster discovery and device connectivity.



**Note** Cisco Discovery Protocol bypass is not supported and may cause a port go into err-disabled state.

Follow these steps to disable Cisco Discovery Protocol on a port.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device (config)# <code>interface gigabitethernet 1/0/1</code>	Specifies the interface on which you are disabling Cisco Discovery Protocol, and enters interface configuration mode.
<b>Step 4</b>	<b>no cdp enable</b> <b>Example:</b> Device (config-if)# <code>no cdp enable</code>	Disables Cisco Discovery Protocol on the interface specified in Step 3.

	Command or Action	Purpose
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Enabling Cisco Discovery Protocol on an Interface

Cisco Discovery Protocol is enabled by default on all supported interfaces to send and to receive Cisco Discovery Protocol information.



**Note** Device clusters and other Cisco devices (such as Cisco IP Phones) regularly exchange Cisco Discovery Protocol messages. Disabling Cisco Discovery Protocol can interrupt cluster discovery and device connectivity.



**Note** Cisco Discovery Protocol bypass is not supported and may cause a port go into err-disabled state.

Follow these steps to enable Cisco Discovery Protocol on a port on which it has been disabled.

### Before you begin

Cisco Discovery Protocol must be disabled on the port that you are trying to Cisco Discovery Protocol enable on, or it cannot be enabled.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
	Device> <b>enable</b>	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface</b> <b>gigabitethernet1/0/1</b>	Specifies the interface on which you are enabling Cisco Discovery Protocol, and enters interface configuration mode.
<b>Step 4</b>	<b>cdp enable</b> <b>Example:</b> Device(config-if)# <b>cdp enable</b>	Enables Cisco Discovery Protocol on a disabled interface.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

## Monitoring and Maintaining Cisco Discovery Protocol

Table 70: Commands for Displaying Cisco Discovery Protocol Information

Command	Description
<b>clear cdp counters</b>	Resets the traffic counters to zero.
<b>clear cdp table</b>	Deletes the Cisco Discovery Protocol table of information about neighbors.



Command	Description
<b>show cdp</b>	Displays global information, such as frequency of transmissions and the holdtime for packets being sent.
<b>show cdp entry</b> <i>entry-name</i> [ <b>version</b> ] [ <b>protocol</b> ]	Displays information about a specific neighbor.  You can enter an asterisk (*) to display all Cisco Discovery Protocol neighbors, or you can enter the name of the neighbor about which you want information.  You can also limit the display to information about the protocols enabled on the specified neighbor or information about the version of software running on the device.
<b>show cdp interface</b> [ <i>interface-id</i> ]	Displays information about interfaces where Cisco Discovery Protocol is enabled.  You can limit the display to the interface about which you want information.
<b>show cdp neighbors</b> [ <i>interface-id</i> ] [ <i>detail</i> ]	Displays information about neighbors, including device type, interface type and number, holdtime settings, capabilities, platform, and port ID.  You can limit the display to neighbors of a specific interface or expand the display to provide more detailed information.
<b>show cdp traffic</b>	Displays Cisco Discovery Protocol counters, including the number of packets sent and received and checksum errors.

## Additional References

### Related Documents

Related Topic	Document Title
System Management Commands	<i>Network Management Command Reference, Cisco IOS XE Release 3E</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**Standards and RFCs**

Standard/RFC	Title
None	-

**MIBs**

MIB	MIBs Link
All supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>



## CHAPTER 71

# Configuring Simple Network Management Protocol

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- [Prerequisites for SNMP, on page 1045](#)
- [Restrictions for SNMP, on page 1047](#)
- [Information About SNMP, on page 1047](#)
- [How to Configure SNMP, on page 1051](#)
- [Monitoring SNMP Status, on page 1067](#)
- [SNMP Examples, on page 1068](#)
- [Additional References, on page 1069](#)
- [Feature History and Information for Simple Network Management Protocol, on page 1070](#)

## Prerequisites for SNMP

### Supported SNMP Versions

This software release supports the following SNMP versions:

- **SNMPv1**—The Simple Network Management Protocol, a Full Internet Standard, defined in RFC 1157.
- **SNMPv2C** replaces the Party-based Administrative and Security Framework of SNMPv2Classic with the community-string-based Administrative Framework of SNMPv2C while retaining the bulk retrieval and improved error handling of SNMPv2Classic. It has these features:
  - **SNMPv2**—Version 2 of the Simple Network Management Protocol, a Draft Internet Standard, defined in RFCs 1902 through 1907.
  - **SNMPv2C**—The community-string-based Administrative Framework for SNMPv2, an Experimental Internet Protocol defined in RFC 1901.
- **SNMPv3**—Version 3 of the SNMP is an interoperable standards-based protocol defined in RFCs 2273 to 2275. SNMPv3 provides secure access to devices by authenticating and encrypting packets over the network and includes these security features:
  - **Message integrity**—Ensures that a packet was not tampered with in transit.
  - **Authentication**—Determines that the message is from a valid source.

- Encryption—Mixes the contents of a package to prevent it from being read by an unauthorized source.



**Note** To select encryption, enter the **priv** keyword.

Both SNMPv1 and SNMPv2C use a community-based form of security. The community of managers able to access the agent's MIB is defined by an IP address access control list and password.

SNMPv2C includes a bulk retrieval function and more detailed error message reporting to management stations. The bulk retrieval function retrieves tables and large quantities of information, minimizing the number of round-trips required. The SNMPv2C improved error-handling includes expanded error codes that distinguish different kinds of error conditions; these conditions are reported through a single error code in SNMPv1. Error return codes in SNMPv2C report the error type.

SNMPv3 provides for both security models and security levels. A security model is an authentication strategy set up for a user and the group within which the user resides. A security level is the permitted level of security within a security model. A combination of the security level and the security model determine which security method is used when handling an SNMP packet. Available security models are SNMPv1, SNMPv2C, and SNMPv3.

The following table identifies characteristics and compares different combinations of security models and levels:

**Table 71: SNMP Security Models and Levels**

Model	Level	Authentication	Encryption	Result
SNMPv1	noAuthNoPriv	Community string	No	Uses a community string match for authentication.
SNMPv2C	noAuthNoPriv	Community string	No	Uses a community string match for authentication.
SNMPv3	noAuthNoPriv	Username	No	Uses a username match for authentication.
SNMPv3	authNoPriv	Message Digest 5 (MD5) or Secure Hash Algorithm (SHA)	No	Provides authentication based on the HMAC-MD5 or HMAC-SHA algorithms.

Model	Level	Authentication	Encryption	Result
SNMPv3	authPriv	MD5 or SHA	Data Encryption Standard (DES) or Advanced Encryption Standard (AES)	<p>Provides authentication based on the HMAC-MD5 or HMAC-SHA algorithms.</p> <p>Allows specifying the User-based Security Model (USM) with these encryption algorithms:</p> <ul style="list-style-type: none"> <li>• DES 56-bit encryption in addition to authentication based on the CBC-DES (DES-56) standard.</li> <li>• 3DES 168-bit encryption</li> <li>• AES 128-bit, 192-bit, or 256-bit encryption</li> </ul>

You must configure the SNMP agent to use the SNMP version supported by the management station. Because an agent can communicate with multiple managers, you can configure the software to support communications using SNMPv1, SNMPv2C, or SNMPv3.

## Restrictions for SNMP

### Version Restrictions

- SNMPv1 does not support informs.

## Information About SNMP

### SNMP Overview

SNMP is an application-layer protocol that provides a message format for communication between managers and agents. The SNMP system consists of an SNMP manager, an SNMP agent, and a management information

base (MIB). The SNMP manager can be part of a network management system (NMS) such as Cisco Prime Infrastructure. The agent and MIB reside on the device. To configure SNMP on the device, you define the relationship between the manager and the agent.

The SNMP agent contains MIB variables whose values the SNMP manager can request or change. A manager can get a value from an agent or store a value into the agent. The agent gathers data from the MIB, the repository for information about device parameters and network data. The agent can also respond to a manager's requests to get or set data.

An agent can send unsolicited traps to the manager. Traps are messages alerting the SNMP manager to a condition on the network. Traps can mean improper user authentication, restarts, link status (up or down), MAC address tracking, closing of a TCP connection, loss of connection to a neighbor, or other significant events.

## SNMP Manager Functions

The SNMP manager uses information in the MIB to perform the operations described in the following table:

**Table 72: SNMP Operations**

Operation	Description
get-request	Retrieves a value from a specific variable.
get-next-request	Retrieves a value from a variable within a table. <sup>3</sup>
get-bulk-request <sup>4</sup>	Retrieves large blocks of data, such as multiple rows in a table, that would otherwise require the transmission of many small blocks of data.
get-response	Replies to a get-request, get-next-request, and set-request sent by an NMS.
set-request	Stores a value in a specific variable.
trap	An unsolicited message sent by an SNMP agent to an SNMP manager when some event has occurred.

<sup>3</sup> With this operation, an SNMP manager does not need to know the exact variable name. A sequential search is performed to find the needed variable from within a table.

<sup>4</sup> The get-bulk command only works with SNMPv2 or later.

## SNMP Agent Functions

The SNMP agent responds to SNMP manager requests as follows:

- Get a MIB variable—The SNMP agent begins this function in response to a request from the NMS. The agent retrieves the value of the requested MIB variable and responds to the NMS with that value.
- Set a MIB variable—The SNMP agent begins this function in response to a message from the NMS. The SNMP agent changes the value of the MIB variable to the value requested by the NMS.

The SNMP agent also sends unsolicited trap messages to notify an NMS that a significant event has occurred on the agent. Examples of trap conditions include, but are not limited to, when a port or module goes up or down, when spanning-tree topology changes occur, and when authentication failures occur.

## SNMP Community Strings

SNMP community strings authenticate access to MIB objects and function as embedded passwords. In order for the NMS to access the device, the community string definitions on the NMS must match at least one of the three community string definitions on the device.

A community string can have one of the following attributes:

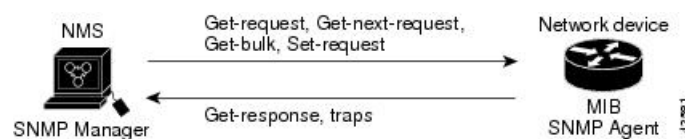
- Read-only (RO)—Gives all objects in the MIB except the community strings read access to authorized management stations, but does not allow write access.
- Read-write (RW)—Gives all objects in the MIB read and write access to authorized management stations, but does not allow access to the community strings.
- When a cluster is created, the command device manages the exchange of messages among member devices and the SNMP application. The Network Assistant software appends the member device number (@esN, where N is the device number) to the first configured RW and RO community strings on the command device and propagates them to the member devices.

## SNMP MIB Variables Access

An example of an NMS is the Cisco Prime Infrastructure network management software. Cisco Prime Infrastructure 2.0 software uses the device MIB variables to set device variables and to poll devices on the network for specific information. The results of a poll can be displayed as a graph and analyzed to troubleshoot internetworking problems, increase network performance, verify the configuration of devices, monitor traffic loads, and more.

As shown in the figure, the SNMP agent gathers data from the MIB. The agent can send traps, or notification of certain events, to the SNMP manager, which receives and processes the traps. Traps alert the SNMP manager to a condition on the network such as improper user authentication, restarts, link status (up or down), MAC address tracking, and so forth. The SNMP agent also responds to MIB-related queries sent by the SNMP manager in *get-request*, *get-next-request*, and *set-request* format.

Figure 80: SNMP Network



## SNMP Notifications

SNMP allows the device to send notifications to SNMP managers when particular events occur. SNMP notifications can be sent as traps or inform requests. In command syntax, unless there is an option in the command to select either traps or informs, the keyword traps refers to either traps or informs, or both. Use the `snmp-server host` command to specify whether to send SNMP notifications as traps or informs.



**Note** SNMPv1 does not support informs.

Traps are unreliable because the receiver does not send an acknowledgment when it receives a trap, and the sender cannot determine if the trap was received. When an SNMP manager receives an inform request, it acknowledges the message with an SNMP response protocol data unit (PDU). If the sender does not receive a response, the inform request can be sent again. Because they can be resent, informs are more likely than traps to reach their intended destination.

The characteristics that make informs more reliable than traps also consume more resources in the device and in the network. Unlike a trap, which is discarded as soon as it is sent, an inform request is held in memory until a response is received or the request times out. Traps are sent only once, but an inform might be resent or retried several times. The retries increase traffic and contribute to a higher overhead on the network. Therefore, traps and informs require a trade-off between reliability and resources. If it is important that the SNMP manager receive every notification, use inform requests. If traffic on the network or memory in the device is a concern and notification is not required, use traps.

## SNMP ifIndex MIB Object Values

The SNMP agent's IF-MIB module comes up shortly after reboot. As various physical interface drivers are initialized they register with the IF-MIB module, essentially saying "Give me an ifIndex number". The IF-MIB module assigns the next available ifIndex number on a first-come-first-served basis. That is, minor differences in driver initialization order from one reboot to another can result in the same physical interface getting a different ifIndex number than it had before the reboot (unless ifIndex persistency is enabled of course).

## Default SNMP Configuration

Feature	Default Setting
SNMP agent	Disabled <sup>5</sup> .
SNMP trap receiver	None configured.
SNMP traps	None enabled except the trap for TCP connections (tty).
SNMP version	If no version keyword is present, the default is Version 1.
SNMPv3 authentication	If no keyword is entered, the default is the <b>noauth</b> (noAuthNoPriv) security level.
SNMP notification type	If no type is specified, all notifications are sent.

<sup>5</sup> This is the default when the device starts and the startup configuration does not have any **snmp-server** global configuration commands.

## SNMP Configuration Guidelines

If the device starts and the device startup configuration has at least one **snmp-server** global configuration command, the SNMP agent is enabled.

An SNMP *group* is a table that maps SNMP users to SNMP views. An SNMP *user* is a member of an SNMP group. An SNMP *host* is the recipient of an SNMP trap operation. An SNMP *engine ID* is a name for the local or remote SNMP engine.

When configuring SNMP, follow these guidelines:



- When configuring an SNMP group, do not specify a notify view. The **snmp-server host** global configuration command auto-generates a notify view for the user and then adds it to the group associated with that user. Modifying the group's notify view affects all users associated with that group.
- To configure a remote user, specify the IP address or port number for the remote SNMP agent of the device where the user resides.
- Before you configure remote users for a particular agent, configure the SNMP engine ID, using the **snmp-server engineID** global configuration command with the **remote** option. The remote agent's SNMP engine ID and user password are used to compute the authentication and privacy digests. If you do not configure the remote engine ID first, the configuration command fails.
- When configuring SNMP informs, you need to configure the SNMP engine ID for the remote agent in the SNMP database before you can send proxy requests or informs to it.
- If a local user is not associated with a remote host, the device does not send informs for the **auth** (authNoPriv) and the **priv** (authPriv) authentication levels.
- Changing the value of the SNMP engine ID has significant results. A user's password (entered on the command line) is converted to an MD5 or SHA security digest based on the password and the local engine ID. The command-line password is then destroyed, as required by RFC 2274. Because of this deletion, if the value of the engine ID changes, the security digests of SNMPv3 users become invalid, and you need to reconfigure SNMP users by using the **snmp-server user** *username* global configuration command. Similar restrictions require the reconfiguration of community strings when the engine ID changes.

## How to Configure SNMP

### Disabling the SNMP Agent

The **no snmp-server** global configuration command disables all running versions (Version 1, Version 2C, and Version 3) of the SNMP agent on the device. You reenables all versions of the SNMP agent by the first **snmp-server** global configuration command that you enter. There is no Cisco IOS command specifically designated for enabling SNMP.

Follow these steps to disable the SNMP agent.

#### Before you begin

The SNMP Agent must be enabled before it can be disabled. The SNMP agent is enabled by the first **snmp-server** global configuration command entered on the device.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>no snmp-server</b> <b>Example:</b> Device(config)# <code>no snmp-server</code>	Disables the SNMP agent operation.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b> Device# <code>show running-config</code>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring Community Strings

You use the SNMP community string to define the relationship between the SNMP manager and the agent. The community string acts like a password to permit access to the agent on the device. Optionally, you can specify one or more of these characteristics associated with the string:

- An access list of IP addresses of the SNMP managers that are permitted to use the community string to gain access to the agent
- A MIB view, which defines the subset of all MIB objects accessible to the given community
- Read and write or read-only permission for the MIB objects accessible to the community

Follow these steps to configure a community string on the device.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>snmp-server community <i>string</i> [view <i>view-name</i>] [ro   rw] [access-list-number]</b> <b>Example:</b> <pre>Device(config)# snmp-server community comaccess ro 4</pre>	Configures the community string. <p><b>Note</b> The @ symbol is used for delimiting the context information. Avoid using the @ symbol as part of the SNMP community string when configuring this command.</p> <ul style="list-style-type: none"> <li>• For <i>string</i>, specify a string that acts like a password and permits access to the SNMP protocol. You can configure one or more community strings of any length.</li> <li>• (Optional) For <b>view</b>, specify the view record accessible to the community.</li> <li>• (Optional) Specify either read-only (<b>ro</b>) if you want authorized management stations to retrieve MIB objects, or specify read-write (<b>rw</b>) if you want authorized management stations to retrieve and modify MIB objects. By default, the community string permits read-only access to all objects.</li> <li>• (Optional) For <i>access-list-number</i>, enter an IP standard access list numbered from 1 to 99 and 1300 to 1999.</li> </ul>
<b>Step 4</b>	<b>access-list <i>access-list-number</i> {deny   permit} <i>source</i> [<i>source-wildcard</i>]</b> <b>Example:</b> <pre>Device(config)# access-list 4 deny any</pre>	(Optional) If you specified an IP standard access list number in Step 3, then create the list, repeating the command as many times as necessary. <ul style="list-style-type: none"> <li>• For <i>access-list-number</i>, enter the access list number specified in Step 3.</li> <li>• The <b>deny</b> keyword denies access if the conditions are matched. The <b>permit</b></li> </ul>

	Command or Action	Purpose
		<p>keyword permits access if the conditions are matched.</p> <ul style="list-style-type: none"> <li>• For <i>source</i>, enter the IP address of the SNMP managers that are permitted to use the community string to gain access to the agent.</li> <li>• (Optional) For <i>source-wildcard</i>, enter the wildcard bits in dotted decimal notation to be applied to the source. Place ones in the bit positions that you want to ignore.</li> </ul> <p>Recall that the access list is always terminated by an implicit deny statement for everything.</p>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 7</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

### What to do next

To disable access for an SNMP community, set the community string for that community to the null string (do not enter a value for the community string).

To remove a specific community string, use the **no snmp-server** community string global configuration command.

You can specify an identification name (engine ID) for the local or remote SNMP server engine on the device. You can configure an SNMP server group that maps SNMP users to SNMP views, and you can add new users to the SNMP group.

## Configuring SNMP Groups and Users

You can specify an identification name (engine ID) for the local or remote SNMP server engine on the device. You can configure an SNMP server group that maps SNMP users to SNMP views, and you can add new users to the SNMP group.

Follow these steps to configure SNMP groups and users on the device.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>snmp-server engineID</b> { <b>local</b> <i>engineid-string</i>   <b>remote</b> <i>ip-address</i> [ <b>udp-port</b> <i>port-number</i> ] <i>engineid-string</i> } <b>Example:</b> Device(config)# <b>snmp-server engineID local 1234</b>	Configures a name for either the local or remote copy of SNMP. <ul style="list-style-type: none"> <li>• The <i>engineid-string</i> is a 24-character ID string with the name of the copy of SNMP. You need not specify the entire 24-character engine ID if it has trailing zeros. Specify only the portion of the engine ID up to the point where only zeros remain in the value. The Step Example configures an engine ID of 123400000000000000000000.</li> <li>• If you select <b>remote</b>, specify the <i>ip-address</i> of the device that contains the remote copy of SNMP and the optional User Datagram Protocol (UDP) port on the remote device. The default is 162.</li> </ul>
<b>Step 4</b>	<b>snmp-server group</b> <i>group-name</i> { <b>v1</b>   <b>v2c</b>   <b>v3</b> { <b>auth</b>   <b>noauth</b>   <b>priv</b> } } [ <b>read</b> <i>readview</i> ] [ <b>write</b> <i>writeview</i> ] [ <b>notify</b> <i>notifyview</i> ] [ <b>access</b> <i>access-list</i> ] <b>Example:</b> Device(config)# <b>snmp-server group public v2c access lmnop</b>	Configures a new SNMP group on the remote device. For <i>group-name</i> , specify the name of the group. Specify one of the following security models: <ul style="list-style-type: none"> <li>• <b>v1</b> is the least secure of the possible security models.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>v2c</b> is the second least secure model. It allows transmission of informs and integers twice the normal width.</li> <li>• <b>v3</b>, the most secure, requires you to select one of the following authentication levels: <ul style="list-style-type: none"> <li><b>auth</b>—Enables the Message Digest 5 (MD5) and the Secure Hash Algorithm (SHA) packet authentication.</li> <li><b>noauth</b>—Enables the noAuthNoPriv security level. This is the default if no keyword is specified.</li> <li><b>priv</b>—Enables Data Encryption Standard (DES) packet encryption (also called privacy).</li> </ul> </li> </ul> <p>(Optional) Enter <b>read</b> <i>readview</i> with a string (not to exceed 64 characters) that is the name of the view in which you can only view the contents of the agent.</p> <p>(Optional) Enter <b>write</b> <i>writeview</i> with a string (not to exceed 64 characters) that is the name of the view in which you enter data and configure the contents of the agent.</p> <p>(Optional) Enter <b>notify</b> <i>notifyview</i> with a string (not to exceed 64 characters) that is the name of the view in which you specify a notify, inform, or trap.</p> <p>(Optional) Enter <b>access</b> <i>access-list</i> with a string (not to exceed 64 characters) that is the name of the access list.</p>
<b>Step 5</b>	<p><b>snmp-server user</b> <i>username group-name</i> { <b>remote</b> <i>host</i> [ <b>udp-port</b> <i>port</i> ] } { <b>v1</b> [ <b>access</b> <i>access-list</i> ]   <b>v2c</b> [ <b>access</b> <i>access-list</i> ]   <b>v3</b> [ <b>encrypted</b> ] [ <b>access</b> <i>access-list</i> ] [ <b>auth</b> { <b>md5</b>   <b>sha</b> } <i>auth-password</i> ] } [ <b>priv</b> { <b>des</b>   <b>3des</b>   <b>aes</b> { <b>128</b>   <b>192</b>   <b>256</b> } } ] <i>priv-password</i> ]</p> <p><b>Example:</b></p> <pre>Device(config)# snmp-server user Pat public v2c</pre>	<p>Adds a new user for an SNMP group.</p> <p>The <i>username</i> is the name of the user on the host that connects to the agent.</p> <p>The <i>group-name</i> is the name of the group to which the user is associated.</p> <p>Enter <b>remote</b> to specify a remote SNMP entity to which the user belongs and the hostname or IP address of that entity with the optional UDP port number. The default is 162.</p> <p>Enter the SNMP version number (<b>v1</b>, <b>v2c</b>, or <b>v3</b>). If you enter <b>v3</b>, you have these additional options:</p>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>encrypted</b> specifies that the password appears in encrypted format. This keyword is available only when the <b>v3</b> keyword is specified.</li> <li>• <b>auth</b> is an authentication level setting session that can be either the HMAC-MD5-96 (<b>md5</b>) or the HMAC-SHA-96 (<b>sha</b>) authentication level and requires a password string <i>auth-password</i> (not to exceed 64 characters).</li> </ul> <p>If you enter <b>v3</b> you can also configure a private (<b>priv</b>) encryption algorithm and password string <i>priv-password</i> using the following keywords (not to exceed 64 characters):</p> <ul style="list-style-type: none"> <li>• <b>priv</b> specifies the User-based Security Model (USM).</li> <li>• <b>des</b> specifies the use of the 56-bit DES algorithm.</li> <li>• <b>3des</b> specifies the use of the 168-bit DES algorithm.</li> <li>• <b>aes</b> specifies the use of the DES algorithm. You must select either 128-bit, 192-bit, or 256-bit encryption.</li> </ul> <p>(Optional) Enter <b>access</b> <i>access-list</i> with a string (not to exceed 64 characters) that is the name of the access list.</p>
<b>Step 6</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config</pre>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	<code>startup-config</code>	

## Configuring SNMP Notifications

A trap manager is a management station that receives and processes traps. Traps are system alerts that the device generates when certain events occur. By default, no trap manager is defined, and no traps are sent. Devices running this Cisco IOS release can have an unlimited number of trap managers.



**Note** Many commands use the word **traps** in the command syntax. Unless there is an option in the command to select either traps or informs, the keyword **traps** refers to traps, informs, or both. Use the **snmp-server host** global configuration command to specify whether to send SNMP notifications as traps or informs.

You can use the **snmp-server enable traps** global configuration command combined with the **snmp-server host** global configuration command for a specific host to receive the notification types listed in the following table. You can enable any or all of these traps and configure a trap manager to receive them.



**Note** The **snmp-server enable traps** command does not support traps for local-authentication on your device.

*Table 73: Device Notification Types*

Notification Type Keyword	Description
<b>bridge</b>	Generates STP bridge MIB traps.
<b>cluster</b>	Generates a trap when the cluster configuration changes.
<b>config</b>	Generates a trap for SNMP configuration changes.
<b>copy-config</b>	Generates a trap for SNMP copy configuration changes.
<b>cpu threshold</b>	Allow CPU-related traps.
<b>entity</b>	Generates a trap for SNMP entity changes.
<b>envmon</b>	Generates environmental monitor traps. You can enable any or all of these environmental traps: fan, shutdown, status, supply, temperature.
<b>flash</b>	Generates SNMP FLASH notifications. In a device stack, you can optionally enable notification for flash insertion or removal, which would cause a trap to be issued whenever a device in the stack is removed or inserted (physical removal, power cycle, or reload).
<b>fru-ctrl</b>	Generates entity field-replaceable unit (FRU) control traps. In the device stack, this trap refers to the insertion or removal of a device in the stack.
<b>hsrp</b>	Generates a trap for Hot Standby Router Protocol (HSRP) changes.



Notification Type Keyword	Description
<b>ipmulticast</b>	Generates a trap for IP multicast routing changes.
<b>mac-notification</b>	Generates a trap for MAC address notifications.
<b>ospf</b>	Generates a trap for Open Shortest Path First (OSPF) changes. You can enable any or all of these traps: Cisco specific, errors, link-state advertisement, rate limit, retransmit, and state changes.
<b>pim</b>	Generates a trap for Protocol-Independent Multicast (PIM) changes. You can enable any or all of these traps: invalid PIM messages, neighbor changes, and rendezvous point (RP)-mapping changes.
<b>port-security</b>	<p>Generates SNMP port security traps. You can also set a maximum trap rate per second. The range is from 0 to 1000; the default is 0, which means that there is no rate limit.</p> <p><b>Note</b> When you configure a trap by using the notification type <b>port-security</b>, configure the port security trap first, and then configure the port security trap rate:</p> <ol style="list-style-type: none"> <li><b>snmp-server enable traps port-security</b></li> <li><b>snmp-server enable traps port-security trap-rate <i>rate</i></b></li> </ol>
<b>snmp</b>	Generates a trap for SNMP-type notifications for authentication, cold start, warm start, link up or link down.
<b>storm-control</b>	Generates a trap for SNMP storm-control. You can also set a maximum trap rate per minute. The range is from 0 to 1000; the default is 0 (no limit is imposed; a trap is sent at every occurrence).
<b>stpx</b>	Generates SNMP STP Extended MIB traps.
<b>syslog</b>	Generates SNMP syslog traps.
<b>tty</b>	Generates a trap for TCP connections. This trap is enabled by default.
<b>vlan-membership</b>	Generates a trap for SNMP VLAN membership changes.
<b>vlancreate</b>	Generates SNMP VLAN created traps.
<b>vlandelete</b>	Generates SNMP VLAN deleted traps.
<b>vtp</b>	Generates a trap for VLAN Trunking Protocol (VTP) changes.

Follow these steps to configure the device to send traps or informs to a host.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>snmp-server engineID remote ip-address engineid-string</b> <b>Example:</b> <pre>Device(config)# snmp-server engineID remote 192.180.1.27 00000063000100a1c0b4011b</pre>	Specifies the engine ID for the remote host.
<b>Step 4</b>	<b>snmp-server user username group-name {remote host [udp-port port]} {v1 [access access-list]   v2c [access access-list]   v3 [encrypted] [access access-list] [auth {md5   sha} auth-password]}</b> <b>Example:</b> <pre>Device(config)# snmp-server user Pat public v2c</pre>	Configures an SNMP user to be associated with the remote host created in Step 3. <b>Note</b> You cannot configure a remote user for an address without first configuring the engine ID for the remote host. Otherwise, you receive an error message, and the command is not executed.
<b>Step 5</b>	<b>snmp-server group group-name {v1   v2c   v3 {auth   noauth   priv}} [read readview] [write writeview] [notify notifyview] [access access-list]</b> <b>Example:</b> <pre>Device(config)# snmp-server group public v2c access lmnop</pre>	Configures an SNMP group.
<b>Step 6</b>	<b>snmp-server host host-addr [informs   traps] [version {1   2c   3 {auth   noauth   priv}}] community-string [notification-type]</b> <b>Example:</b> <pre>Device(config)# snmp-server host 203.0.113.1 comaccess snmp</pre>	Specifies the recipient of an SNMP trap operation. For <i>host-addr</i> , specify the name or Internet address of the host (the targeted recipient). (Optional) Specify <b>traps</b> (the default) to send SNMP traps to the host. (Optional) Specify <b>informs</b> to send SNMP informs to the host. (Optional) Specify the SNMP <b>version</b> ( <b>1</b> , <b>2c</b> , or <b>3</b> ). SNMPv1 does not support informs. (Optional) For Version 3, select authentication level <b>auth</b> , <b>noauth</b> , or <b>priv</b> . <b>Note</b> The <b>priv</b> keyword is available only when the cryptographic software image is installed.

	Command or Action	Purpose
		<p>For <i>community-string</i>, when <b>version 1</b> or <b>version 2c</b> is specified, enter the password-like community string sent with the notification operation. When <b>version 3</b> is specified, enter the SNMPv3 username.</p> <p>The @ symbol is used for delimiting the context information. Avoid using the @ symbol as part of the SNMP community string when configuring this command.</p> <p>(Optional) For <i>notification-type</i>, use the keywords listed in the table above. If no type is specified, all notifications are sent.</p> <p><b>Note</b> In case of SNMP version 3, SNMPv3 user should be configured prior SNMPv3 host configuration, otherwise SNMP traps will not be sent.</p>
<b>Step 7</b>	<p><b>snmp-server enable traps</b> <i>notification-types</i></p> <p><b>Example:</b></p> <pre>Device(config)# snmp-server enable traps snmp</pre>	<p>Enables the device to send traps or informs and specifies the type of notifications to be sent. For a list of notification types, see the table above, or enter <b>snmp-server enable traps ?</b></p> <p>To enable multiple types of traps, you must enter a separate <b>snmp-server enable traps</b> command for each trap type.</p> <p><b>Note</b> When you configure a trap by using the notification type <b>port-security</b>, configure the port security trap first, and then configure the port security trap rate:</p> <ol style="list-style-type: none"> <li>a. <b>snmp-server enable traps port-security</b></li> <li>b. <b>snmp-server enable traps port-security trap-rate rate</b></li> </ol>
<b>Step 8</b>	<p><b>snmp-server trap-source</b> <i>interface-id</i></p> <p><b>Example:</b></p> <pre>Device(config)# snmp-server trap-source gigabitethernet 1/0/1</pre>	<p>(Optional) Specifies the source interface, which provides the IP address for the trap message. This command also sets the source IP address for informs.</p>

	Command or Action	Purpose
<b>Step 9</b>	<b>snmp-server queue-length</b> <i>length</i> <b>Example:</b> Device(config)# <b>snmp-server queue-length</b> 20	(Optional) Establishes the message queue length for each trap host. The range is 1 to 5000; the default is 10.
<b>Step 10</b>	<b>snmp-server trap-timeout</b> <i>seconds</i> <b>Example:</b> Device(config)# <b>snmp-server trap-timeout</b> 60	(Optional) Defines how often to resend trap messages. The range is 1 to 1000; the default is 30 seconds.
<b>Step 11</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 12</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 13</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

**What to do next**

The **snmp-server host** command specifies which hosts receive the notifications. The **snmp-server enable traps** command globally enables the method for the specified notification (for traps and informs). To enable a host to receive an inform, you must configure an **snmp-server host informs** command for the host and globally enable informs by using the **snmp-server enable traps** command.

To remove the specified host from receiving traps, use the **no snmp-server host** *host* global configuration command. The **no snmp-server host** command with no keywords disables traps, but not informs, to the host. To disable informs, use the **no snmp-server host informs** global configuration command. To disable a specific trap type, use the **no snmp-server enable traps** *notification-types* global configuration command.

## Setting the Agent Contact and Location Information

Follow these steps to set the system contact and location of the SNMP agent so that these descriptions can be accessed through the configuration file.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>snmp-server contact <i>text</i></b> <b>Example:</b> Device(config)# <b>snmp-server contact Dial System Operator at beeper 21555</b>	Sets the system contact string.
<b>Step 4</b>	<b>snmp-server location <i>text</i></b> <b>Example:</b> Device(config)# <b>snmp-server location Building 3/Room 222</b>	Sets the system location string.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Limiting TFTP Servers Used Through SNMP

Follow these steps to limit the TFTP servers used for saving and loading configuration files through SNMP to the servers specified in an access list.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>snmp-server tftp-server-list</b> <i>access-list-number</i> <b>Example:</b> Device(config)# <b>snmp-server</b> <b>tftp-server-list 44</b>	Limits the TFTP servers used for configuration file copies through SNMP to the servers in the access list.  For <i>access-list-number</i> , enter an IP standard access list numbered from 1 to 99 and 1300 to 1999.
<b>Step 4</b>	<b>access-list</b> <i>access-list-number</i> { <b>deny</b>   <b>permit</b> } <i>source</i> [ <i>source-wildcard</i> ] <b>Example:</b> Device(config)# <b>access-list 44 permit</b> <b>10.1.1.2</b>	Creates a standard access list, repeating the command as many times as necessary.  For <i>access-list-number</i> , enter the access list number specified in Step 3.  The <b>deny</b> keyword denies access if the conditions are matched. The <b>permit</b> keyword permits access if the conditions are matched.  For <i>source</i> , enter the IP address of the TFTP servers that can access the device.  (Optional) For <i>source-wildcard</i> , enter the wildcard bits, in dotted decimal notation, to be applied to the source. Place ones in the bit positions that you want to ignore.  The access list is always terminated by an implicit deny statement for everything.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b>	Verifies your entries.

	Command or Action	Purpose
	Device# <code>show running-config</code>	
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring Trap Flags for SNMP

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>trapflags ap { interfaceup   register}</b> <b>Example:</b> Device(config)# <code>trapflags ap interfaceup</code>	Enables sending AP-related traps. Use the <b>no</b> form of the command to disable the trap flags. <ul style="list-style-type: none"> <li>• <b>interfaceup</b>– Enables trap when a Cisco AP interface (A or B) comes up.</li> <li>• <b>register</b>– Enables trap when a Cisco AP registers with a Cisco device.</li> </ul>
<b>Step 3</b>	<b>trapflags client { dot11   excluded}</b> <b>Example:</b> Device(config)# <code>trapflags client excluded</code>	Enables sending client-related dot11 traps. Use the <b>no</b> form of the command to disable the trap flags. <ul style="list-style-type: none"> <li>• <b>dot11</b>– Enables Dot11 traps for clients.</li> <li>• <b>excluded</b>– Enables excluded traps for clients.</li> </ul>
<b>Step 4</b>	<b>trapflags dot11-security {ids-sig-attack   wep-decrypt-error}</b> <b>Example:</b> Device(config)# <code>trapflags dot11-security wep-decrypt-error</code>	Enables sending 802.11 security-related traps. Use the <b>no</b> form of the command to disable the trap flags. <ul style="list-style-type: none"> <li>• <b>ids-sig-attack</b>– Enables IDS signature attack traps.</li> <li>• <b>wep-decrypt-error</b>– Enables traps for WEP decrypt error for clients.</li> </ul>

	Command or Action	Purpose
<b>Step 5</b>	<b>trapflags mesh</b> <b>Example:</b> <pre>Device(config)# trapflags mesh</pre>	Enables trap for the mesh. Use the <b>no</b> form of the command to disable the trap flags.
<b>Step 6</b>	<b>trapflags rogueap</b> <b>Example:</b> <pre>Device(config)# trapflags rogueap</pre>	Enables trap for rogue AP detection. Use the <b>no</b> form of the command to disable the trap flags.
<b>Step 7</b>	<b>trapflags rrm-params {channels   tx-power}</b> <b>Example:</b> <pre>Device(config)# trapflags rrm-params tx-power</pre>	Enables sending RRM-parameter update-related traps. Use the <b>no</b> form of the command to disable the trap flags. <ul style="list-style-type: none"> <li>• <b>channels</b>– Enables trap when RF Manager automatically changes a channel number for the Cisco AP interface.</li> <li>• <b>tx-power</b>– Enables the trap when RF Manager automatically changes Tx-Power level for the Cisco AP interface.</li> </ul>
<b>Step 8</b>	<b>trapflags rrm-profile {coverage   interference   load   noise}</b> <b>Example:</b> <pre>Device(config)# trapflags rrm-profile interference</pre>	Enables sending RRM-profile-related traps. Use the <b>no</b> form of the command to disable the trap flags. <ul style="list-style-type: none"> <li>• <b>coverage</b>– Enables the trap when the coverage profile maintained by RF Manager fails.</li> <li>• <b>interference</b>– Enables the trap when the interference profile maintained by RF Manager fails.</li> <li>• <b>load</b>– Enables trap when the load profile maintained by RF Manager fails.</li> <li>• <b>noise</b>– Enables trap when the noise profile maintained by RF Manager fails.</li> </ul>
<b>Step 9</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.



## Enabling SNMP Wireless Trap Notification

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>snmp-server enable traps wireless</b> [ <b>AP</b>   <b>RRM</b>   <b>bsn80211SecurityTrap</b>   <b>bsnAPPParamUpdate</b>   <b>bsnAPPProfile</b>   <b>bsnAccessPoint</b>   <b>bsnMobileStation</b>   <b>bsnRogue</b>   <b>client</b>   <b>mfp</b>   <b>rogue</b> ] <b>Example:</b> Device(config)# <code>snmp-server enable traps wireless AP</code>	Enables SNMP wireless trap notification. <ul style="list-style-type: none"> <li>• <b>AP</b>– Enables access point traps.</li> <li>• <b>RRM</b>– Enables RRM traps.</li> <li>• <b>bsn80211SecurityTrap</b>– Enables the security-related trap.</li> <li>• <b>bsnAPPParamUpdate</b>– Enables the trap for AP parameters that get updated.</li> <li>• <b>bsnAPPProfile</b>– Enables BSN AP profile traps.</li> <li>• <b>bsnAccessPoint</b>– Enables BSN access point traps.</li> <li>• <b>bsnMobileStation</b>– Controls wireless client traps.</li> <li>• <b>bsnRogue</b>– Enables BSN rogue-related traps.</li> <li>• <b>client</b>– Enables client traps.</li> <li>• <b>mfp</b>– Enables MFP traps.</li> <li>• <b>rogue</b>– Enables rogue-related traps.</li> </ul>
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.

## Monitoring SNMP Status

To display SNMP input and output statistics, including the number of illegal community string entries, errors, and requested variables, use the **show snmp** privileged EXEC command. You also can use the other privileged EXEC commands listed in the table to display SNMP information.

Table 74: Commands for Displaying SNMP Information

Command	Purpose
<code>show snmp</code>	Displays SNMP statistics.
<code>show snmp engineID</code>	Displays information on the local SNMP engine and all remote engines that have been configured on the device.
<code>show snmp group</code>	Displays information on each SNMP group on the network.
<code>show snmp pending</code>	Displays information on pending SNMP requests.
<code>show snmp sessions</code>	Displays information on the current SNMP sessions.
<code>show snmp user</code>	<p>Displays information on each SNMP user name in the SNMP users table.</p> <p><b>Note</b> You must use this command to display SNMPv3 configuration information for <b>auth</b>   <b>noauth</b>   <b>priv</b> mode. This information is not displayed in the <b>show running-config</b> output.</p>

## SNMP Examples

This example shows how to enable all versions of SNMP. The configuration permits any SNMP manager to access all objects with read-only permissions using the community string *public*. This configuration does not cause the device to send any traps.

```
Device(config)# snmp-server community public
```

This example shows how to permit any SNMP manager to access all objects with read-only permission using the community string *public*. The device also sends VTP traps to the hosts 192.180.1.111 and 192.180.1.33 using SNMPv1 and to the host 192.180.1.27 using SNMPv2C. The community string *public* is sent with the traps.

```
Device(config)# snmp-server community public
Device(config)# snmp-server enable traps vtp
Device(config)# snmp-server host 192.180.1.27 version 2c public
Device(config)# snmp-server host 192.180.1.111 version 1 public
Device(config)# snmp-server host 192.180.1.33 public
```

This example shows how to allow read-only access for all objects to members of access list 4 that use the *comaccess* community string. No other SNMP managers have access to any objects. SNMP Authentication Failure traps are sent by SNMPv2C to the host *cisco.com* using the community string *public*.

```
Device(config)# snmp-server community comaccess ro 4
Device(config)# snmp-server enable traps snmp authentication
Device(config)# snmp-server host cisco.com version 2c public
```

This example shows how to send Entity MIB traps to the host *cisco.com*. The community string is restricted. The first line enables the device to send Entity MIB traps in addition to any traps previously enabled. The

second line specifies the destination of these traps and overwrites any previous **snmp-server** host commands for the host *cisco.com*.

```
Device(config)# snmp-server enable traps entity
Device(config)# snmp-server host cisco.com restricted entity
```

This example shows how to enable the device to send all traps to the host *myhost.cisco.com* using the community string *public*:

```
Device(config)# snmp-server enable traps
Device(config)# snmp-server host myhost.cisco.com public
```

This example shows how to associate a user with a remote host and to send **auth** (authNoPriv) authentication-level informs when the user enters global configuration mode:

```
Device(config)# snmp-server engineID remote 192.180.1.27 00000063000100a1c0b4011b
Device(config)# snmp-server group authgroup v3 auth
Device(config)# snmp-server user authuser authgroup remote 192.180.1.27 v3 auth md5 mypassword
Device(config)# snmp-server user authuser authgroup v3 auth md5 mypassword
Device(config)# snmp-server host 192.180.1.27 informs version 3 auth authuser config
Device(config)# snmp-server enable traps
Device(config)# snmp-server inform retries 0
```

## Additional References

### Related Documents

Related Topic	Document Title
SNMP Commands	<i>Network Management Command Reference, Cisco IOS XE Release 3E</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### Standards and RFCs

Standard/RFC	Title
None	-

### MIBs

MIB	MIBs Link
All supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for Simple Network Management Protocol

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.



## CHAPTER 72

# Configuring Service Level Agreements

This chapter describes how to use Cisco IOS IP Service Level Agreements (SLAs) on the switch.

Unless otherwise noted, the term *switch* refers to a standalone switch or a switch stack.

- [Restrictions on SLAs, on page 1071](#)
- [Information About SLAs, on page 1071](#)
- [How to Configure IP SLAs Operations, on page 1076](#)
- [Monitoring IP SLA Operations, on page 1089](#)
- [Monitoring IP SLA Operation Examples, on page 1090](#)
- [Additional References, on page 1091](#)

## Restrictions on SLAs

This section lists the restrictions on SLAs.

The following are restrictions on IP SLAs network performance measurement:

- The device does not support VoIP service levels using the gatekeeper registration delay operations measurements.
- Only a Cisco IOS device can be a source for a destination IP SLAs responder.
- You cannot configure the IP SLAs responder on non-Cisco devices and Cisco IOS IP SLAs can send operational packets only to services native to those devices.

## Information About SLAs

### Cisco IOS IP Service Level Agreements (SLAs)

Cisco IOS IP SLAs send data across the network to measure performance between multiple network locations or across multiple network paths. They simulate network data and IP services and collect network performance information in real time. Cisco IOS IP SLAs generate and analyze traffic either between Cisco IOS devices or from a Cisco IOS device to a remote IP device such as a network application server. Measurements provided by the various Cisco IOS IP SLA operations can be used for troubleshooting, for problem analysis, and for designing network topologies.

Depending on the specific Cisco IOS IP SLA operations, various network performance statistics are monitored within the Cisco device and stored in both command-line interface (CLI) and Simple Network Management Protocol (SNMP) MIBs. IP SLA packets have configurable IP and application layer options such as source and destination IP address, User Datagram Protocol (UDP)/TCP port numbers, a type of service (ToS) byte (including Differentiated Services Code Point [DSCP] and IP Prefix bits), Virtual Private Network (VPN) routing/forwarding instance (VRF), and URL web address.

Because Cisco IP SLAs are Layer 2 transport independent, you can configure end-to-end operations over disparate networks to best reflect the metrics that an end user is likely to experience. IP SLAs collect and analyze the following performance metrics:

- Delay (both round-trip and one-way)
- Jitter (directional)
- Packet loss (directional)
- Packet sequencing (packet ordering)
- Path (per hop)
- Connectivity (directional)
- Server or website download time

Because Cisco IOS IP SLAs is SNMP-accessible, it can also be used by performance-monitoring applications like Cisco Prime Internetwork Performance Monitor (IPM) and other third-party Cisco partner performance management products.

Using IP SLAs can provide the following benefits:

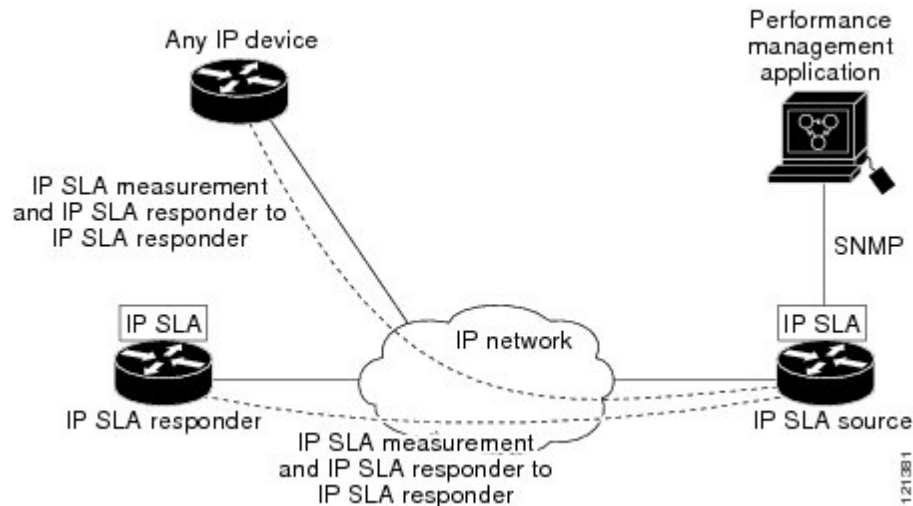
- Service-level agreement monitoring, measurement, and verification.
- Network performance monitoring
  - Measurement of jitter, latency, or packet loss in the network.
  - Continuous, reliable, and predictable measurements.
- IP service network health assessment to verify that the existing QoS is sufficient for new IP services.
- Edge-to-edge network availability monitoring for proactive verification and connectivity testing of network resources (for example, shows the network availability of an NFS server used to store business critical data from a remote site).
- Network operation troubleshooting by providing consistent, reliable measurement that immediately identifies problems and saves troubleshooting time.
- Multiprotocol Label Switching (MPLS) performance monitoring and network verification (if the device supports MPLS).

## Network Performance Measurement with Cisco IOS IP SLAs

You can use IP SLAs to monitor the performance between any area in the network—core, distribution, and edge—without deploying a physical probe. It uses generated traffic to measure network performance between two networking devices.

**Figure 81: Cisco IOS IP SLAs Operation**

The following figure shows how IP SLAs begin when the source device sends a generated packet to the destination device. After the destination device receives the packet, depending on the type of IP SLAs operation, it responds with time-stamp information for the source to make the calculation on performance metrics. An IP SLAs operation performs a network measurement from the source device to a destination in the network using a specific protocol such as UDP.



## IP SLA Responder and IP SLA Control Protocol

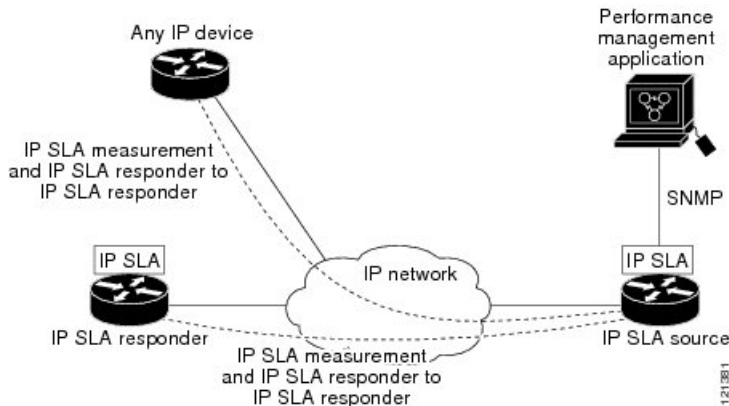
The IP SLA responder is a component embedded in the destination Cisco device that allows the system to anticipate and respond to IP SLA request packets. The responder provides accurate measurements without the need for dedicated probes. The responder uses the Cisco IOS IP SLA Control Protocol to provide a mechanism through which it can be notified on which port it should listen and respond.



**Note** The IP SLA responder can be a Cisco IOS Layer 2, responder-configurable device. The responder does not need to support full IP SLA functionality.

The following figure shows where the Cisco IOS IP SLA responder fits in the IP network. The responder listens on a specific port for control protocol messages sent by an IP SLA operation. Upon receipt of the control message, it enables the specified UDP or TCP port for the specified duration. During this time, the responder accepts the requests and responds to them. It disables the port after it responds to the IP SLA packet, or when the specified time expires. MD5 authentication for control messages is available for added security.

Figure 82: Cisco IOS IP SLAs Operation



You do not need to enable the responder on the destination device for all IP SLA operations. For example, a responder is not required for services that are already provided by the destination router (such as Telnet or HTTP).

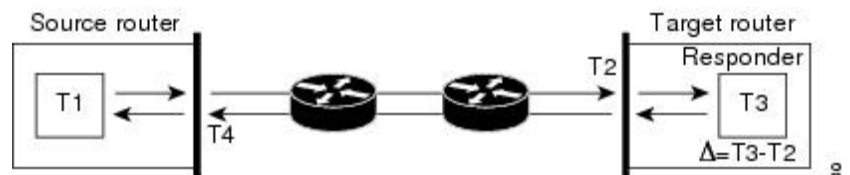
## Response Time Computation for IP SLAs

Switches, controllers, and routers can take tens of milliseconds to process incoming packets due to other high priority processes. This delay affects the response times because the test-packet reply might be in a queue while waiting to be processed. In this situation, the response times would not accurately represent true network delays. IP SLAs minimize these processing delays on the source device as well as on the target device (if the responder is being used) to determine true round-trip times. IP SLA test packets use time stamping to minimize the processing delays.

When the IP SLA responder is enabled, it allows the target device to take time stamps when the packet arrives on the interface at interrupt level and again just as it is leaving, eliminating the processing time. This time stamping is made with a granularity of sub-milliseconds (ms).

Figure 83: Cisco IOS IP SLA Responder Time Stamping

The following figure demonstrates how the responder works. Four time stamps are taken to make the calculation for round-trip time. At the target router, with the responder functionality enabled, time stamp 2 (TS2) is subtracted from time stamp 3 (TS3) to produce the time spent processing the test packet as represented by delta. This delta value is then subtracted from the overall round-trip time. Notice that the same principle is applied by IP SLAs on the source router where the incoming time stamp 4 (TS4) is also taken at the interrupt



level to allow for greater accuracy.  $RTT$  (Round-trip time) =  $T4$  (Time stamp 4) -  $T1$  (Time stamp 1) -  $\Delta$

An additional benefit of the two time stamps at the target device is the ability to track one-way delay, jitter, and directional packet loss. Because much network behavior is asynchronous, it is critical to have these statistics. However, to capture one-way delay measurements, you must configure both the source router and target router with Network Time Protocol (NTP) so that the source and target are synchronized to the same clock source. One-way jitter measurements do not require clock synchronization.



## IP SLAs Operation Scheduling

When you configure an IP SLAs operation, you must schedule the operation to begin capturing statistics and collecting error information. You can schedule an operation to start immediately or to start at a certain month, day, and hour. You can use the *pending* option to set the operation to start at a later time. The pending option is an internal state of the operation that is visible through SNMP. The pending state is also used when an operation is a reaction (threshold) operation waiting to be triggered. You can schedule a single IP SLAs operation or a group of operations at one time.

You can schedule several IP SLAs operations by using a single command through the Cisco IOS CLI or the CISCO RTTMON-MIB. Scheduling the operations to run at evenly distributed times allows you to control the amount of IP SLAs monitoring traffic. This distribution of IP SLA operations helps minimize the CPU utilization and thus improves network scalability.

For more details about the IP SLA multi-operations scheduling functionality, see the “IP SLAs—Multiple Operation Scheduling” chapter of the *Cisco IOS IP SLAs Configuration Guide*.

## IP SLA Operation Threshold Monitoring

To support successful service level agreement monitoring, you must have mechanisms that notify you immediately of any possible violation. IP SLAs can send SNMP traps that are triggered by events such as the following:

- Connection loss
- Timeout
- Round-trip time threshold
- Average jitter threshold
- One-way packet loss
- One-way jitter
- One-way mean opinion score (MOS)
- One-way latency

An IP SLA threshold violation can also trigger another IP SLA operation for further analysis. For example, the frequency could be increased or an Internet Control Message Protocol (ICMP) path echo or ICMP path jitter operation could be initiated for troubleshooting.

### ICMP Echo

The ICMP echo operation measures the end-to-end response time between a Cisco device and any other device that uses IP. The response time is computed by measuring the time it takes to send an ICMP echo request message to a destination and receive an ICMP echo reply. Many customers use IP SLA ICMP-based operations, in-house ping testing, or ping-based dedicated probes to measure this response time. The IP SLA ICMP echo operation conforms to the same specifications as ICMP ping testing, and both methods result in the same response times.

## UDP Jitter

Jitter is a simple term that describes interpacket delay variance. When multiple packets are sent consecutively at an interval of 10 ms from source to destination, the destination should receive them 10 ms apart (if the network is behaving correctly). However, if there are delays in the network (such as queuing, arriving through alternate routes, and so on), the time interval between packet arrivals might be more or less than 10 ms. A positive jitter value indicates that the packets arrived more than 10 ms apart. A negative jitter value indicates that the packets arrived less than 10 ms apart. If the packets arrive 12 ms apart, the positive jitter is 2 ms; if the packets arrive 8 ms apart, the negative jitter is 2 ms. For delay-sensitive networks, positive jitter values are undesirable, and a jitter value of 0 is ideal.

In addition to monitoring jitter, the IP SLA UDP jitter operation can be used as a multipurpose data gathering operation. The packets generated by IP SLAs carry sequence information and time stamps from the source and operational target that include packet sending and receiving data. Based on this data, UDP jitter operations measure the following:

- Per-direction jitter (source to destination and destination to source)
- Per-direction packet-loss
- Per-direction delay (one-way delay)
- Round-trip delay (average round-trip time)

Because the paths for the sending and receiving of data can be different (asymmetric), you can use the per-direction data to more readily identify where congestion or other problems are occurring in the network.

The UDP jitter operation generates synthetic (simulated) UDP traffic and sends a number of UDP packets, each of a specified size, sent a specified number of milliseconds apart, from a source router to a target router, at a given frequency. By default, ten packet-frames, each with a payload size of 10 bytes are generated every 10 ms, and the operation is repeated every 60 seconds. You can configure each of these parameters to best simulate the IP service you want to provide.

To provide accurate one-way delay (latency) measurements, time synchronization (as provided by NTP) is required between the source and the target device. Time synchronization is not required for the one-way jitter and packet loss measurements. If the time is not synchronized between the source and target devices, one-way jitter and packet loss data is returned, but values of 0 are returned for the one-way delay measurements provided by the UDP jitter operation.

## How to Configure IP SLAs Operations

This section does not include configuration information for all available operations as the configuration information details are included in the *Cisco IOS IP SLAs Configuration Guide*. It does include several operations as examples, including configuring the responder, configuring a UDP jitter operation, which requires a responder, and configuring an ICMP echo operation, which does not require a responder. For details about configuring other operations, see the *Cisco IOS IP SLAs Configuration Guide*.

## Default Configuration

No IP SLAs operations are configured.

## Configuration Guidelines

For information on the IP SLA commands, see the *Cisco IOS IP SLAs Command Reference, Release 12.4T* command reference.

For detailed descriptions and configuration procedures, see the *Cisco IOS IP SLAs Configuration Guide, Release 12.4TL*.

Not all of the IP SLA commands or operations described in the referenced guide are supported on the device. The device supports IP service level analysis by using UDP jitter, UDP echo, HTTP, TCP connect, ICMP echo, ICMP path echo, ICMP path jitter, FTP, DNS, and DHCP, as well as multiple operation scheduling and proactive threshold monitoring. It does not support VoIP service levels using the gatekeeper registration delay operations measurements.

Before configuring any IP SLAs application, you can use the **show ip sla application** privileged EXEC command to verify that the operation type is supported on your software image. This is an example of the output from the command:

```
Device# show ip sla application

      IP Service Level Agreements
Version: Round Trip Time MIB 2.2.0, Infrastructure Engine-III

Supported Operation Types:
      icmpEcho, path-echo, path-jitter, udpEcho, tcpConnect, http
      dns, udpJitter, dhcp, ftp, udpApp, wspApp

Supported Features:
      IPSLAs Event Publisher

IP SLAs low memory water mark: 33299323
Estimated system max number of entries: 24389

Estimated number of configurable operations: 24389
Number of Entries configured      : 0
Number of active Entries          : 0
Number of pending Entries        : 0
Number of inactive Entries       : 0
Time of last change in whole IP SLAs: *13:04:37.668 UTC Wed Dec 19 2012
```

## Configuring the IP SLA Responder

The IP SLA responder is available only on Cisco IOS software-based devices, including some Layer 2 devices that do not support full IP SLA functionality.

Follow these steps to configure the IP SLA responder on the target device (the operational target):

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ip sla responder {tcp-connect   udp-echo}</b> <b>ipaddress ip-address port port-number</b> <b>Example:</b> <pre>Device(config)# ip sla responder udp-echo 172.29.139.134 5000</pre>	Configures the device as an IP SLA responder. The keywords have these meanings: <ul style="list-style-type: none"> <li>• <b>tcp-connect</b>—Enables the responder for TCP connect operations.</li> <li>• <b>udp-echo</b>—Enables the responder for User Datagram Protocol (UDP) echo or jitter operations.</li> <li>• <b>ipaddress ip-address</b>—Enter the destination IP address.</li> <li>• <b>port port-number</b>—Enter the destination port number.</li> </ul> <p><b>Note</b> The IP address and port number must match those configured on the source device for the IP SLA operation.</p>
<b>Step 4</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Implementing IP SLA Network Performance Measurement

Follow these steps to implement IP SLA network performance measurement on your device:

**Before you begin**

Use the **show ip sla application** privileged EXEC command to verify that the desired operation type is supported on your software image.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip sla operation-number</b> <b>Example:</b> Device(config)# <b>ip sla 10</b>	Creates an IP SLA operation, and enters IP SLA configuration mode.
<b>Step 4</b>	<b>udp-jitter</b> <i>{destination-ip-address   destination-hostname}</i> <i>destination-port</i> [ <b>source-ip</b> <i>{ip-address   hostname}</i> ] [ <b>source-port</b> <i>port-number</i> ] [ <b>control</b> { <b>enable</b>   <b>disable</b> }] [ <b>num-packets</b> <i>number-of-packets</i> ] [ <b>interval</b> <i>interpacket-interval</i> ] <b>Example:</b> Device(config-ip-sla)# <b>udp-jitter 172.29.139.134 5000</b>	Configures the IP SLA operation as the operation type of your choice (a UDP jitter operation is used in the example), and enters its configuration mode (UDP jitter configuration mode is used in the example). <ul style="list-style-type: none"> <li>• <i>destination-ip-address</i>   <i>destination-hostname</i>—Specifies the destination IP address or hostname.</li> <li>• <i>destination-port</i>—Specifies the destination port number in the range from 1 to 65535.</li> <li>• (Optional) <b>source-ip</b> <i>{ip-address   hostname}</i>—Specifies the source IP address or hostname. When a source IP address or hostname is not specified, IP SLA chooses the IP address nearest to the destination</li> <li>• (Optional) <b>source-port</b> <i>port-number</i>—Specifies the source port number in the range from 1 to 65535. When a port number is not specified, IP SLA chooses an available port.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• (Optional) <b>control</b>—Enables or disables sending of IP SLA control messages to the IP SLA responder. By default, IP SLA control messages are sent to the destination device to establish a connection with the IP SLA responder</li> <li>• (Optional) <b>num-packets</b> <i>number-of-packets</i>—Enters the number of packets to be generated. The range is 1 to 6000; the default is 10.</li> <li>• (Optional) <b>interval</b> <i>inter-packet-interval</i>—Enters the interval between sending packets in milliseconds. The range is 1 to 6000; the default value is 20 ms.</li> </ul>
<b>Step 5</b>	<b>frequency</b> <i>seconds</i> <b>Example:</b> <pre>Device(config-ip-sla-jitter) # frequency 45</pre>	(Optional) Configures options for the SLA operation. This example sets the rate at which a specified IP SLA operation repeats. The range is from 1 to 604800 seconds; the default is 60 seconds.
<b>Step 6</b>	<b>threshold</b> <i>milliseconds</i> <b>Example:</b> <pre>Device(config-ip-sla-jitter) # threshold 200</pre>	(Optional) Configures threshold conditions. This example sets the threshold of the specified IP SLA operation to 200. The range is from 0 to 60000 milliseconds.
<b>Step 7</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-ip-sla-jitter) # exit</pre>	Exits the SLA operation configuration mode (UDP jitter configuration mode in this example), and returns to global configuration mode.
<b>Step 8</b>	<b>ip sla schedule</b> <i>operation-number</i> [ <b>life</b> { <b>forever</b>   <i>seconds</i> }] [ <b>start-time</b> { <i>hh:mm</i> [: <i>ss</i> ] [ <i>month day</i>   <i>day month</i> ]   <b>pending</b>   <b>now</b>   <b>after</b> <i>hh:mm:ss</i> ] [ <b>ageout</b> <i>seconds</i> ] [ <b>recurring</b> ] <b>Example:</b> <pre>Device(config)# ip sla schedule 10 start-time now life forever</pre>	Configures the scheduling parameters for an individual IP SLA operation. <ul style="list-style-type: none"> <li>• <i>operation-number</i>—Enter the RTR entry number.</li> <li>• (Optional) <b>life</b>—Sets the operation to run indefinitely (<b>forever</b>) or for a specific number of <i>seconds</i>. The range is from 0 to 2147483647. The default is 3600 seconds (1 hour).</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• (Optional) <b>start-time</b>—Enters the time for the operation to begin collecting information:  To start at a specific time, enter the hour, minute, second (in 24-hour notation), and day of the month. If no month is entered, the default is the current month.  Enter <b>pending</b> to select no information collection until a start time is selected.  Enter <b>now</b> to start the operation immediately.  Enter <b>after</b> <i>hh:mm:ss</i> to show that the operation should start after the entered time has elapsed.</li> <li>• (Optional) <b>ageout</b> <i>seconds</i>—Enter the number of seconds to keep the operation in memory when it is not actively collecting information. The range is 0 to 2073600 seconds, the default is 0 seconds (never ages out).</li> <li>• (Optional) <b>recurring</b>—Set the operation to automatically run every day.</li> </ul>
<b>Step 9</b>	<b>end</b>  <b>Example:</b>  Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 10</b>	<b>show running-config</b>  <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 11</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

### UDP Jitter Configuration

This example shows how to configure a UDP jitter IP SLA operation:

```

Device(config)# ip sla 10
Device(config-ip-sla)# udp-jitter 172.29.139.134 5000
Device(config-ip-sla-jitter)# frequency 30
Device(config-ip-sla-jitter)# exit
Device(config)# ip sla schedule 5 start-time now life forever
Device(config)# end
Device# show ip sla configuration 10
IP SLAs, Infrastructure Engine-II.

Entry number: 10
Owner:
Tag:
Type of operation to perform: udp-jitter
Target address/Source address: 1.1.1.1/0.0.0.0
Target port/Source port: 2/0
Request size (ARR data portion): 32
Operation timeout (milliseconds): 5000
Packet Interval (milliseconds)/Number of packets: 20/10
Type Of Service parameters: 0x0
Verify data: No
Vrf Name:
Control Packets: enabled
Schedule:
  Operation frequency (seconds): 30
  Next Scheduled Start Time: Pending trigger
  Group Scheduled : FALSE
  Randomly Scheduled : FALSE
  Life (seconds): 3600
  Entry Ageout (seconds): never
  Recurring (Starting Everyday): FALSE
  Status of entry (SNMP RowStatus): notInService
Threshold (milliseconds): 5000
Distribution Statistics:
  Number of statistic hours kept: 2
  Number of statistic distribution buckets kept: 1
  Statistic distribution interval (milliseconds): 20
Enhanced History:

```

## Analyzing IP Service Levels by Using the UDP Jitter Operation

Follow these steps to configure a UDP jitter operation on the source device:

### Before you begin

You must enable the IP SLA responder on the target device (the operational target) to configure a UDP jitter operation on the source device.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>



	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip sla operation-number</b> <b>Example:</b> Device(config)# <b>ip sla 10</b>	Creates an IP SLA operation, and enters IP SLA configuration mode.
<b>Step 4</b>	<b>udp-jitter</b> { <i>destination-ip-address</i>   <i>destination-hostname</i> } <i>destination-port</i> [ <b>source-ip</b> { <i>ip-address</i>   <i>hostname</i> }] [ <b>source-port</b> <i>port-number</i> ] [ <b>control</b> { <b>enable</b>   <b>disable</b> }] [ <b>num-packets</b> <i>number-of-packets</i> ] [ <b>interval</b> <i>interpacket-interval</i> ] <b>Example:</b> Device(config-ip-sla)# <b>udp-jitter 172.29.139.134 5000</b>	Configures the IP SLA operation as a UDP jitter operation, and enters UDP jitter configuration mode. <ul style="list-style-type: none"> <li>• <i>destination-ip-address</i>   <i>destination-hostname</i>—Specifies the destination IP address or hostname.</li> <li>• <i>destination-port</i>—Specifies the destination port number in the range from 1 to 65535.</li> <li>• (Optional) <b>source-ip</b> {<i>ip-address</i>   <i>hostname</i>}—Specifies the source IP address or hostname. When a source IP address or hostname is not specified, IP SLA chooses the IP address nearest to the destination.</li> <li>• (Optional) <b>source-port</b> <i>port-number</i>—Specifies the source port number in the range from 1 to 65535. When a port number is not specified, IP SLA chooses an available port.</li> <li>• (Optional) <b>control</b>—Enables or disables sending of IP SLA control messages to the IP SLA responder. By default, IP SLA control messages are sent to the destination device to establish a connection with the IP SLA responder.</li> <li>• (Optional) <b>num-packets</b> <i>number-of-packets</i>—Enters the number of packets to be generated. The range is 1 to 6000; the default is 10.</li> <li>• (Optional) <b>interval</b> <i>inter-packet-interval</i>—Enters the interval between sending packets in milliseconds.</li> </ul>

	Command or Action	Purpose
		The range is 1 to 6000; the default value is 20 ms.
<b>Step 5</b>	<b>frequency</b> <i>seconds</i> <b>Example:</b> <pre>Device(config-ip-sla-jitter)# <b>frequency</b> 45</pre>	(Optional) Sets the rate at which a specified IP SLA operation repeats. The range is from 1 to 604800 seconds; the default is 60 seconds.
<b>Step 6</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-ip-sla-jitter)# <b>exit</b></pre>	Exits UDP jitter configuration mode, and returns to global configuration mode.
<b>Step 7</b>	<b>ip sla schedule</b> <i>operation-number</i> [ <b>life</b> { <b>forever</b>   <i>seconds</i> }] [ <b>start-time</b> { <i>hh:mm</i> [: <i>ss</i> ] [ <i>month day</i>   <i>day month</i> ]   <b>pending</b>   <b>now</b>   <b>after</b> <i>hh:mm:ss</i> }] [ <b>ageout</b> <i>seconds</i> ] [ <b>recurring</b> ] <b>Example:</b> <pre>Device(config)# <b>ip sla schedule</b> 10 <b>start-time now life forever</b></pre>	<p>Configures the scheduling parameters for an individual IP SLA operation.</p> <ul style="list-style-type: none"> <li>• <i>operation-number</i>—Enter the RTR entry number.</li> <li>• (Optional) <b>life</b>—Sets the operation to run indefinitely (<b>forever</b>) or for a specific number of <i>seconds</i>. The range is from 0 to 2147483647. The default is 3600 seconds (1 hour).</li> <li>• (Optional) <b>start-time</b>—Enters the time for the operation to begin collecting information: <ul style="list-style-type: none"> <li>To start at a specific time, enter the hour, minute, second (in 24-hour notation), and day of the month. If no month is entered, the default is the current month.</li> <li>Enter <b>pending</b> to select no information collection until a start time is selected.</li> <li>Enter <b>now</b> to start the operation immediately.</li> <li>Enter <b>after</b> <i>hh:mm:ss</i> to show that the operation should start after the entered time has elapsed.</li> </ul> </li> <li>• (Optional) <b>ageout</b> <i>seconds</i>—Enter the number of seconds to keep the operation in memory when it is not actively collecting information. The range is 0 to 2073600 seconds, the default is 0 seconds (never ages out).</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• (Optional) <b>recurring</b>—Set the operation to automatically run every day.</li> </ul>
<b>Step 8</b>	<b>end</b> <b>Example:</b> Device (config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 9</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 10</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

### Configuring a UDP Jitter IP SLA Operation

This example shows how to configure a UDP jitter IP SLA operation:

```

Device(config)# ip sla 10
Device(config-ip-sla)# udp-jitter 172.29.139.134 5000
Device(config-ip-sla-jitter)# frequency 30
Device(config-ip-sla-jitter)# exit
Device(config)# ip sla schedule 5 start-time now life forever
Device(config)# end
Device# show ip sla configuration 10
IP SLAs, Infrastructure Engine-II.

Entry number: 10
Owner:
Tag:
Type of operation to perform: udp-jitter
Target address/Source address: 1.1.1.1/0.0.0.0
Target port/Source port: 2/0
Request size (ARR data portion): 32
Operation timeout (milliseconds): 5000
Packet Interval (milliseconds)/Number of packets: 20/10
Type Of Service parameters: 0x0
Verify data: No
Vrf Name:
Control Packets: enabled
Schedule:
  Operation frequency (seconds): 30
  Next Scheduled Start Time: Pending trigger
  Group Scheduled : FALSE
  Randomly Scheduled : FALSE

```

```

Life (seconds): 3600
Entry Ageout (seconds): never
Recurring (Starting Everyday): FALSE
Status of entry (SNMP RowStatus): notInService
Threshold (milliseconds): 5000
Distribution Statistics:
  Number of statistic hours kept: 2
  Number of statistic distribution buckets kept: 1
  Statistic distribution interval (milliseconds): 20
Enhanced History:

```

## Analyzing IP Service Levels by Using the ICMP Echo Operation

Follow these steps to configure an ICMP echo operation on the source device:

### Before you begin

This operation does not require the IP SLA responder to be enabled.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip sla operation-number</b> <b>Example:</b> Device (config)# <b>ip sla 10</b>	Creates an IP SLA operation and enters IP SLA configuration mode.
<b>Step 4</b>	<b>icmp-echo</b> { <i>destination-ip-address</i>   <i>destination-hostname</i> } [ <b>source-ip</b> { <i>ip-address</i>   <i>hostname</i> }   <b>source-interface</b> <i>interface-id</i> ] <b>Example:</b> Device (config-ip-sla)# <b>icmp-echo 172.29.139.134</b>	Configures the IP SLA operation as an ICMP Echo operation and enters ICMP echo configuration mode. <ul style="list-style-type: none"> <li>• <i>destination-ip-address</i>   <i>destination-hostname</i>—Specifies the destination IP address or hostname.</li> <li>• (Optional) <b>source-ip</b> {<i>ip-address</i>   <i>hostname</i>}—Specifies the source IP address or hostname. When a source IP address or hostname is not specified, IP</li> </ul>

	Command or Action	Purpose
		<p>SLA chooses the IP address nearest to the destination.</p> <ul style="list-style-type: none"> <li>(Optional) <b>source-interface interface-id</b>—Specifies the source interface for the operation.</li> </ul>
<b>Step 5</b>	<p><b>frequency</b> <i>seconds</i></p> <p><b>Example:</b></p> <pre>Device(config-ip-sla-echo)# frequency 30</pre>	<p>(Optional) Sets the rate at which a specified IP SLA operation repeats. The range is from 1 to 604800 seconds; the default is 60 seconds.</p>
<b>Step 6</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-ip-sla-echo)# exit</pre>	<p>Exits UDP echo configuration mode, and returns to global configuration mode.</p>
<b>Step 7</b>	<p><b>ip sla schedule</b> <i>operation-number</i> [<b>life</b> {<b>forever</b>   <i>seconds</i>}] [<b>start-time</b> {<i>hh:mm</i> [:<i>ss</i>] [<i>month day</i>   <i>day month</i>]   <b>pending</b>   <b>now</b>   <b>after</b> <i>hh:mm:ss</i>] [<b>ageout</b> <i>seconds</i>] [<b>recurring</b>]</p> <p><b>Example:</b></p> <pre>Device(config)# ip sla schedule 5 start-time now life forever</pre>	<p>Configures the scheduling parameters for an individual IP SLA operation.</p> <ul style="list-style-type: none"> <li><i>operation-number</i>—Enter the RTR entry number.</li> <li>(Optional) <b>life</b>—Sets the operation to run indefinitely (<b>forever</b>) or for a specific number of <i>seconds</i>. The range is from 0 to 2147483647. The default is 3600 seconds (1 hour)</li> <li>(Optional) <b>start-time</b>—Enter the time for the operation to begin collecting information: <ul style="list-style-type: none"> <li>To start at a specific time, enter the hour, minute, second (in 24-hour notation), and day of the month. If no month is entered, the default is the current month.</li> <li>Enter <b>pending</b> to select no information collection until a start time is selected.</li> <li>Enter <b>now</b> to start the operation immediately.</li> <li>Enter <b>after</b> <i>hh:mm:ss</i> to indicate that the operation should start after the entered time has elapsed.</li> </ul> </li> <li>(Optional) <b>ageout</b> <i>seconds</i>—Enter the number of seconds to keep the operation</li> </ul>

	Command or Action	Purpose
		<p>in memory when it is not actively collecting information. The range is 0 to 2073600 seconds; the default is 0 seconds (never ages out).</p> <ul style="list-style-type: none"> <li>• (Optional) <b>recurring</b>—Sets the operation to automatically run every day.</li> </ul>
<b>Step 8</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 9</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 10</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

### Configuring an ICMP Echo IP SLA Operation

This example shows how to configure an ICMP echo IP SLA operation:

```
Device(config)# ip sla 12
Device(config-ip-sla)# icmp-echo 172.29.139.134
Device(config-ip-sla-echo)# frequency 30
Device(config-ip-sla-echo)# exit
Device(config)# ip sla schedule 5 start-time now life forever
Device(config)# end
Device# show ip sla configuration 22
IP SLAs, Infrastructure Engine-II.
```

```
Entry number: 12
Owner:
Tag:
Type of operation to perform: echo
Target address: 2.2.2.2
Source address: 0.0.0.0
Request size (ARR data portion): 28
Operation timeout (milliseconds): 5000
Type Of Service parameters: 0x0
Verify data: No
Vrf Name:
Schedule:
```

```

Operation frequency (seconds): 60
Next Scheduled Start Time: Pending trigger
Group Scheduled : FALSE
Randomly Scheduled : FALSE
Life (seconds): 3600
Entry Ageout (seconds): never
Recurring (Starting Everyday): FALSE
Status of entry (SNMP RowStatus): notInService
Threshold (milliseconds): 5000
Distribution Statistics:
  Number of statistic hours kept: 2
  Number of statistic distribution buckets kept: 1
  Statistic distribution interval (milliseconds): 20
History Statistics:
  Number of history Lives kept: 0
  Number of history Buckets kept: 15
  History Filter Type: None
Enhanced History:

```

## Monitoring IP SLA Operations

The following table describes the commands used to display IP SLA operation configurations and results:

**Table 75: Monitoring IP SLA Operations**

<b>show ip sla application</b>	Displays global information about Cisco IOS IP SLAs.
<b>show ip sla authentication</b>	Displays IP SLA authentication information.
<b>show ip sla configuration</b> [ <i>entry-number</i> ]	Displays configuration values including all defaults for all IP SLA operations or a specific operation.
<b>show ip sla enhanced-history</b> { <i>collection-statistics</i>   <i>distribution statistics</i> } [ <i>entry-number</i> ]	Displays enhanced history statistics for collected history buckets or distribution statistics for all IP SLA operations or a specific operation.
<b>show ip sla ethernet-monitor configuration</b> [ <i>entry-number</i> ]	Displays IP SLA automatic Ethernet configuration.
<b>show ip sla group schedule</b> [ <i>schedule-entry-number</i> ]	Displays IP SLA group scheduling configuration and details.
<b>show ip sla history</b> [ <i>entry-number</i>   <b>full</b>   <b>tabular</b> ]	Displays history collected for all IP SLA operations.
<b>show ip sla mpls-lsp-monitor</b> { <i>collection-statistics</i>   <i>configuration</i>   <i>ldp operational-state</i>   <i>scan-queue</i>   <i>summary</i> [ <i>entry-number</i> ]   <i>neighbors</i> }	Displays MPLS label switched path (LSP) Health Monitor operations.
<b>show ip sla reaction-configuration</b> [ <i>entry-number</i> ]	Displays the configured proactive threshold monitoring settings for all IP SLA operations or a specific operation.
<b>show ip sla reaction-trigger</b> [ <i>entry-number</i> ]	Displays the reaction trigger information for all IP SLA operations or a specific operation.

<b>show ip sla responder</b>	Displays information about the IP SLA responder.
<b>show ip sla statistics</b> [ <i>entry-number</i>   <b>aggregated</b>   <b>details</b> ]	Displays current or aggregated operational status and statistics.

## Monitoring IP SLA Operation Examples

The following example shows all IP SLAs by application:

```
Device# show ip sla application

      IP Service Level Agreements
Version: Round Trip Time MIB 2.2.0, Infrastructure Engine-III

Supported Operation Types:
      icmpEcho, path-echo, path-jitter, udpEcho, tcpConnect, http
      dns, udpJitter, dhcp, ftp, udpApp, wspApp

Supported Features:
      IPSLAs Event Publisher

IP SLAs low memory water mark: 33299323
Estimated system max number of entries: 24389

Estimated number of configurable operations: 24389
Number of Entries configured      : 0
Number of active Entries          : 0
Number of pending Entries         : 0
Number of inactive Entries        : 0
Time of last change in whole IP SLAs: *13:04:37.668 UTC Wed Dec 19 2012
```

The following example shows all IP SLA distribution statistics:

```
Device# show ip sla enhanced-history distribution-statistics

Point by point Enhanced History
Entry   = Entry Number
Int     = Aggregation Interval
BucI    = Bucket Index
StartT  = Aggregation Start Time
Pth     = Path index
Hop     = Hop in path index
Comps   = Operations completed
OvrTh   = Operations completed over thresholds
SumCmp  = Sum of RTT (milliseconds)
SumCmp2L = Sum of RTT squared low 32 bits (milliseconds)
SumCmp2H = Sum of RTT squared high 32 bits (milliseconds)
TMax    = RTT maximum (milliseconds)
TMin    = RTT minimum (milliseconds)

Entry Int BucI StartT      Pth Hop Comps OvrTh SumCmp      SumCmp2L  SumCmp2H  T
Max   TMin
```



# Additional References

## Related Documents

Related Topic	Document Title
Cisco Medianet Metadata Guide	<a href="http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/mdata/configuration/15-sy/mdata-15sy-book/metadata-framework.pdf">http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/mdata/configuration/15-sy/mdata-15sy-book/metadata-framework.pdf</a>
Cisco Media Services Proxy Configuration Guide	<a href="http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/msp/configuration/15-mt/msp-15-mt-book.pdf">http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/msp/configuration/15-mt/msp-15-mt-book.pdf</a>
Cisco Mediatrace and Cisco Performance Monitor Configuration Guide	<a href="http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/media_monitoring/configuration/15-mt/mm-15-mt-book/mm-mediatrace.html">http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/media_monitoring/configuration/15-mt/mm-15-mt-book/mm-mediatrace.html</a>

## Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

## Standards and RFCs

Standard/RFC	Title
None	-

## MIBs

MIB	MIBs Link
All supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>



## CHAPTER 73

# Configuring Local Policies

- [Restrictions for Configuring Local Policies, on page 1093](#)
- [Information About Configuring Local Policies, on page 1093](#)
- [How to Configure Local Policies, on page 1095](#)
- [Monitoring Local Policies, on page 1099](#)
- [Examples: Local Policies Configuration, on page 1100](#)
- [Additional References for Configuring Local Policies, on page 1101](#)
- [Feature History for Performing Local Policies Configuration, on page 1101](#)

## Restrictions for Configuring Local Policies

- The policy map attributes supported on the device are QoS, VLAN, session timeout, and ACL.
- Apple iPhone 6s will get classified as "workstation" after HTTP profiling.

## Information About Configuring Local Policies

Local policies can profile devices based on HTTP and DHCP to identify the end devices on the network. Users can configure device-based policies and enforce the policies per user or per device policy on the network.

Local policies allow profiling of mobile devices and basic onboarding of the profiled devices to a specific VLAN. They also assign ACL and QoS or configure session timeouts. You can configure local policies as two separate components:

- Defining policy attributes as service templates specific to clients joining the network and applying policy match criteria.
- Applying match criteria to the policy.

The following policy match attributes are used for configuring local policies:

- Device—Defines the type of device. Windows-based computer, Smart phone, Apple devices such as iPad and iPhone.
- Username—Defines the username of the user.
- User role—Defines the user type or the user group the user belongs to, such as a student or employee.

- MAC—Defines the mac-address of the end point.
- MAC OUI—Defines the mac-address OUI.

Once the device has a match corresponding to these parameters per end point, the policy can be added. Policy enforcement allows basic device on-boarding of mobile devices based on the following session attributes:

- VLAN
- QoS
- ACL
- Session timeout

You can configure these policies and enforce end points with specified policies. The wireless clients are profiled based on MAC OUI and DHCP. The device uses these attributes and predefined classification profiles to identify devices.

### Replacing Default Profile Text File

If a new device is not classified, contact the Cisco support team with the device MAC address. The Cisco support team will provide a new **dc\_default\_profile.txt** file with the MAC address included in the file. You need to replace the **dc\_default\_profile.txt** file with the earlier file. Follow these steps to change the **dc\_default\_profile.txt** file:

1. Stop device classifier by entering this command:  
`device(config)# no device classifier`
2. Copy the file by entering this command:  
`device# device classifier profile location filepath`
3. Start the device classifier by entering this command:  
`device(config)# device classifier`

### Disabling session monitor on trunk ports

On uplink trunk ports, you should not create any session monitoring. By default, session monitoring is enabled. You should disable session monitoring.

1. Enter into global configuration mode by entering this command:  
`device# configure terminal`
2. Enter into interface configuration mode by entering this command:  
`device(config)# interface interface-id`
3. Disable session monitoring by entering this command:  
`device(config-if)# no access-session monitor`

# How to Configure Local Policies

## Configuring Local Policies (CLI)

To configure local policies, complete these procedures:

1. Create a service template.
2. Create an interface template.
3. Create a parameter map.
4. Create a policy map.
5. Apply a local policy on a WLAN.

### Creating an Interface Template (CLI)

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>template <i>interface-template-name</i></b> <b>Example:</b> Device(config)# <b>template</b> <b>cisco-phone-template</b> Device(config-template)#	Enters interface template configuration mode.
<b>Step 3</b>	<b>switchport mode access</b> <b>Example:</b> Device(config-template)# <b>switchport mode</b> <b>access</b>	Sets the interface as a nontrunking nontagged single-VLAN Ethernet interface. An access port can carry traffic in one VLAN only. By default, an access port carries traffic for VLAN1.
<b>Step 4</b>	<b>switchport voice vlan <i>vlan_id</i></b> <b>Example:</b> Device(config-template)# <b>switchport voice</b> <b>vlan 20</b>	Specifies to forward all voice traffic through the specified VLAN. You can specify a value from 1 to 4094.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Creating a Parameter Map (CLI)

Parameter map is preferred to use than class map.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>parameter-map type subscriber</b> <b>attribute-to-service</b> <i>parameter-map-name</i>  <b>Example:</b>  Device(config)# <b>parameter-map type</b> <b>subscriber attribute-to-service</b> <b>Aironet-Policy-para</b>	Specifies the parameter map type and name.
<b>Step 3</b>	<b>map-index map</b> { <b>device-type</b>   <b>mac-address</b>   <b>oui</b>   <b>user-role</b>   <b>username</b> } { <b>eq</b>   <b>not-eq</b>   <b>regex</b> <i>filter-name</i> }  <b>Example:</b>  Device(config-parameter-map-filter)# <b>10</b> <b>map device-type eq</b> <b>"WindowsXP-Workstation"</b>	Specifies parameter map attribute filter criteria.
<b>Step 4</b>	<b>interface-template</b> <i>interface-template-name</i>  <b>Example:</b>  Device(config-parameter-map-filter-submode)# <b>interface-template cisco-phone-template</b> Device(config-parameter-map-filter-submode)#	Enters service template configuration mode.
<b>Step 5</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Creating a Class Map (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>class-map type control subscriber</b> <i>class-map-name</i> { <b>match-all</b>   <b>match-any</b>   <b>match-first</b> }  <b>Example:</b>  Device(config)# <b>class-map type control subscriber CLASS_AC_1 match-all</b>	Specifies the class map type and name.
<b>Step 3</b>	<b>match</b> { <b>device-type</b>   <b>mac-address</b>   <b>oui</b>   <b>username</b>   <b>userrole</b> } <i>filter-type-name</i>  <b>Example:</b>  Device(config-class-map)# <b>match device-type Cisco-IP-Phone-7961</b>	Specifies class map attribute filter criteria.
<b>Step 4</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Creating a Policy Map (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>policy-map type control subscriber</b> <i>policy-map-name</i>  <b>Example:</b>  Device(config)# <b>policy-map type control subscriber Aironet-Policy</b>	Specifies the policy map type.
<b>Step 3</b>	<b>event identity-update</b> { <b>match-all</b>   <b>match-first</b> }  <b>Example:</b>  Device(config-policy-map)# <b>event identity-update match-all</b>	Specifies match criteria to the policy map.
<b>Step 4</b>	<i>class_number</i> <b>class</b> { <i>class_map_name</i>   <b>always</b> } { <b>do-all</b>   <b>do-until-failure</b>   <b>do-until-success</b> }	Configures the local profiling policy class map number and specifies how to perform the action. The class map configuration mode includes the following command options:

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config-class-control-policymap)# 1 class local_policy1_class do-until-success</pre>	<ul style="list-style-type: none"> <li>• <b>always</b>—Executes without doing any matching but return success.</li> <li>• <b>do-all</b>—Executes all the actions.</li> <li>• <b>do-until-failure</b>—Execute all the actions until any match failure is encountered. This is the default value.</li> <li>• <b>do-until-success</b>—Execute all the actions until any match success happens.</li> </ul>
<b>Step 5</b>	<p><i>action-index map attribute-to-service table parameter-map-name</i></p> <p><b>Example:</b></p> <pre>Device(config-policy-map)# 10 map attribute-to-service table Aironet-Policy-para</pre>	Specifies parameter map table to be used.
<b>Step 6</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Applying a Local Policy for a Device on a WLAN (CLI)

### Before you begin

If the service policy contains any device type-based rules in the parameter map, ensure that the device classifier is already enabled.



**Note** You should use the **device classification** command to classify the device for it to be displayed correctly on the show command output.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<p><b>wlan wlan-name</b></p> <p><b>Example:</b></p> <pre>Device(config)# wlan wlan1</pre>	Enters WLAN configuration mode.
<b>Step 3</b>	<p><b>service-policy type control subscriber policymapname</b></p>	Applies local policy to WLAN.



	Command or Action	Purpose
	<b>Example:</b> Device(config-wlan)# <b>service-policy type control subscriber Aironet-Policy</b>	
<b>Step 4</b>	<b>profiling local http (optional)</b> <b>Example:</b> Device(config-wlan)# <b>profiling local http</b>	Enables only profiling of devices based on HTTP protocol (optional).
<b>Step 5</b>	<b>profiling radius http (optional)</b> <b>Example:</b> Device(config-wlan)# <b>profiling radius http</b>	Enables profiling of devices on ISE (optional).
<b>Step 6</b>	<b>no shutdown</b> <b>Example:</b> Device(config-wlan)# <b>no shutdown</b>	Specifies not to shut down the WLAN.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Monitoring Local Policies

The following commands can be used to monitor local policies configured on the device.

**Table 76: Monitoring Local Policies Command**

Command	Purpose
<b>show access-session</b>	Displays the summary of access session with authorization status, method and domain for each client or MAC address displayed.
<b>show access-session cache</b>	Displays the latest classification for the client.
<b>show device classifier attached detail</b>	Displays the latest classification for the client based on parameters such as Mac, DHCP, or HTTP.
<b>show access-session mac mac-address details</b>	Displays the policy mapped, service template used, and attributes for the client.  <b>Note</b> If the <b>show access-session detail</b> command output is not displaying session timeout details, you should enable client profiling with session timeout in client access session and then run the <b>show access-session mac mac-address details</b> command to see the session timeout details.

<pre><b>show access-session mac</b> <i>mac-address policy</i></pre>	<p>Displays the policy mapped, service template used, and attributes for the client.</p> <p>In addition, you can view the <b>Resultant Policy</b> that displays the following information:</p> <ul style="list-style-type: none"> <li>• The final attributes applied to the session when the session has locally configured attributes.</li> <li>• Attributes applied from the server.</li> </ul>
---	---

## Examples: Local Policies Configuration



**Note** At the end of each configuration command line, enter CTRL Z to execute the command and proceed to the next line.

This example shows how to create interface template:

```
Device# configure terminal
Device(config)#template cisco-phone-template
Device(config-template)#switchport mode access
Device(config-template)#switchport voice vlan 20
Device(config-template)# end
```

This example shows how to create parameter map:

```
Device# configure terminal
Device(config)#parameter-map type subscriber attribute-to-service param-wired
Device(config-parameter-map-filter)#10 map device-type regex Cisco-IP-Phone
Device(config-parameter-map-filter-submode)#10 interface-template cisco-phone-template
Device(config-parameter-map)# end
```

This example shows how to create policy map:

```
Device(config)# policy-map type control subscriber apple-tsim
Device(config-policy-map)# event identity-update match-all
Device(config-policy-map)# 1 class always do-until-failure
Device(config-policy-map)# 1 map attribute-to-service table apple-tsim-param
Device(config-policy-map)# end
```

This example shows how to apply policy to a device on a WLAN:

```
Device(config)# wlan wlan1
Device(config-wlan)# client vlan VLAN0054
Device(config-wlan)# profiling local http
Device(config-wlan)# service-policy type control subscriber apple-tsim
Device(config-wlan)# no shutdown
Device# end
```

## Additional References for Configuring Local Policies

### Related Documents

Related Topic	Document Title
Security commands	<i>Security Command Reference Guide, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i>

### Standards and RFCs

Standard/RFC	Title
None	—

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History for Performing Local Policies Configuration

Release	Feature Information
Cisco IOS XE 3E	This feature was introduced.





## CHAPTER 74

# Configuring SPAN and RSPAN

- [Finding Feature Information, on page 1103](#)
- [Prerequisites for SPAN and RSPAN, on page 1103](#)
- [Restrictions for SPAN and RSPAN, on page 1104](#)
- [Information About SPAN and RSPAN, on page 1105](#)
- [How to Configure SPAN and RSPAN, on page 1116](#)
- [Monitoring SPAN and RSPAN Operations, on page 1138](#)
- [SPAN and RSPAN Configuration Examples, on page 1139](#)
- [Additional References, on page 1141](#)
- [Feature History and Information for SPAN and RSPAN, on page 1142](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for SPAN and RSPAN

### SPAN

- You can limit SPAN traffic to specific VLANs by using the **filter vlan** keyword. If a trunk port is being monitored, only traffic on the VLANs specified with this keyword is monitored. By default, all VLANs are monitored on a trunk port.

### RSPAN

- We recommend that you configure an RSPAN VLAN before you configure an RSPAN source or a destination session.

# Restrictions for SPAN and RSPAN

## SPAN

The restrictions for SPAN are as follows:

- On each device, you can configure 66 sessions. A maximum of 8 source sessions can be configured and the remaining sessions can be configured as RSPAN destination sessions. A source session is either a local SPAN session or an RSPAN source session.
- For SPAN sources, you can monitor traffic for a single port or VLAN or a series or range of ports or VLANs for each session. You cannot mix source ports and source VLANs within a single SPAN session.
- The destination port cannot be a source port; a source port cannot be a destination port.
- You cannot have two SPAN sessions using the same destination port.
- When you configure a device port as a SPAN destination port, it is no longer a normal device port; only monitored traffic passes through the SPAN destination port.
- Entering SPAN configuration commands does not remove previously configured SPAN parameters. You must enter the **no monitor session** *{session\_number | all | local | remote}* global configuration command to delete configured SPAN parameters.
- For local SPAN, outgoing packets through the SPAN destination port carry the original encapsulation headers—untagged, ISL, or IEEE 802.1Q—if the **encapsulation replicate** keywords are specified. If the keywords are not specified, the packets are sent in native form.
- You can configure a disabled port to be a source or destination port, but the SPAN function does not start until the destination port and at least one source port or source VLAN are enabled.
- You cannot mix source VLANs and filter VLANs within a single SPAN session.

Traffic monitoring in a SPAN session has the following restrictions:

- Sources can be ports or VLANs, but you cannot mix source ports and source VLANs in the same session.
- Wireshark does not capture egress packets when egress span is active.
- You can run both a local SPAN and an RSPAN source session in the same device or device stack. The device or device stack supports a total of 66 source and RSPAN destination sessions.
- You can configure two separate SPAN or RSPAN source sessions with separate or overlapping sets of SPAN source ports and VLANs. Both switched and routed ports can be configured as SPAN sources and destinations.
- You can have multiple destination ports in a SPAN session, but no more than 64 destination ports per device stack.
- SPAN sessions do not interfere with the normal operation of the device. However, an oversubscribed SPAN destination, for example, a 10-Mb/s port monitoring a 100-Mb/s port, can result in dropped or lost packets.
- When SPAN or RSPAN is enabled, each packet being monitored is sent twice, once as normal traffic and once as a monitored packet. Monitoring a large number of ports or VLANs could potentially generate large amounts of network traffic.

- You can configure SPAN sessions on disabled ports; however, a SPAN session does not become active unless you enable the destination port and at least one source port or VLAN for that session.
- The device does not support a combination of local SPAN and RSPAN in a single session.
  - An RSPAN source session cannot have a local destination port.
  - An RSPAN destination session cannot have a local source port.
  - An RSPAN destination session and an RSPAN source session that are using the same RSPAN VLAN cannot run on the same device or device stack.

## RSPAN

The restrictions for RSPAN are as follows:

- RSPAN does not support BPDU packet monitoring or other Layer 2 device protocols.
- The RSPAN VLAN is configured only on trunk ports and not on access ports. To avoid unwanted traffic in RSPAN VLANs, make sure that the VLAN remote-span feature is supported in all the participating devices.
- RSPAN VLANs are included as sources for port-based RSPAN sessions when source trunk ports have active RSPAN VLANs. RSPAN VLANs can also be sources in SPAN sessions. However, since the device does not monitor spanned traffic, it does not support egress spanning of packets on any RSPAN VLAN identified as the destination of an RSPAN source session on the device.
- If you enable VTP and VTP pruning, RSPAN traffic is pruned in the trunks to prevent the unwanted flooding of RSPAN traffic across the network for VLAN IDs that are lower than 1005.
- To use RSPAN, the switch must be running the LAN Base image.

# Information About SPAN and RSPAN

## SPAN and RSPAN

You can analyze network traffic passing through ports or VLANs by using SPAN or RSPAN to send a copy of the traffic to another port on the device or on another device that has been connected to a network analyzer or other monitoring or security device. SPAN copies (or mirrors) traffic received or sent (or both) on source ports or source VLANs to a destination port for analysis. SPAN does not affect the switching of network traffic on the source ports or VLANs. You must dedicate the destination port for SPAN use. Except for traffic that is required for the SPAN or RSPAN session, destination ports do not receive or forward traffic.

Only traffic that enters or leaves source ports or traffic that enters or leaves source VLANs can be monitored by using SPAN; traffic routed to a source VLAN cannot be monitored. For example, if incoming traffic is being monitored, traffic that gets routed from another VLAN to the source VLAN cannot be monitored; however, traffic that is received on the source VLAN and routed to another VLAN can be monitored.

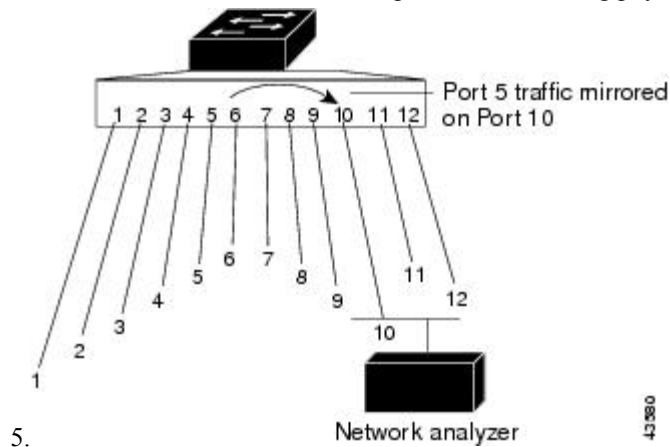
You can use the SPAN or RSPAN destination port to inject traffic from a network security device. For example, if you connect a Cisco Intrusion Detection System (IDS) sensor appliance to a destination port, the IDS device can send TCP reset packets to close down the TCP session of a suspected attacker.

## Local SPAN

Local SPAN supports a SPAN session entirely within one device; all source ports or source VLANs and destination ports are in the same device or device stack. Local SPAN copies traffic from one or more source ports in any VLAN or from one or more VLANs to a destination port for analysis.

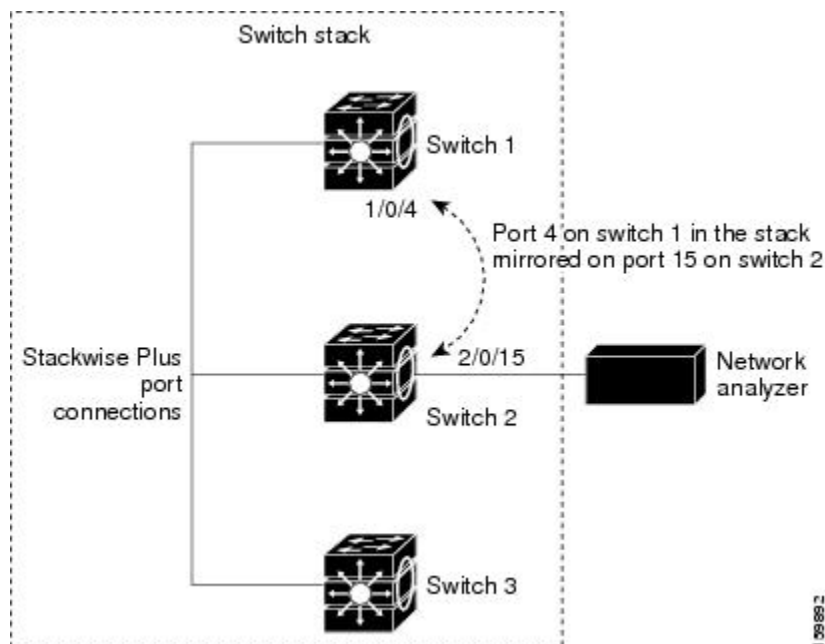
**Figure 84: Example of Local SPAN Configuration on a Single Device**

All traffic on port 5 (the source port) is mirrored to port 10 (the destination port). A network analyzer on port 10 receives all network traffic from port 5 without being physically attached to port



**Figure 85: Example of Local SPAN Configuration on a Device Stack**

This is an example of a local SPAN in a device stack, where the source and destination ports reside on different stack members.



### Related Topics

[Creating a Local SPAN Session](#), on page 1116



[Creating a Local SPAN Session and Configuring Incoming Traffic](#), on page 1119

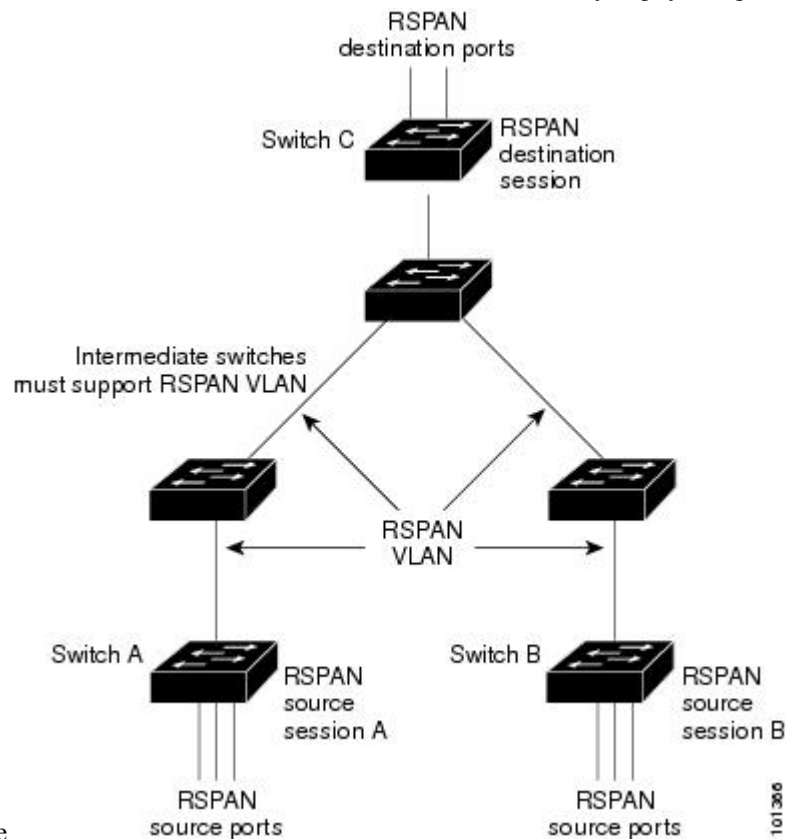
[Example: Configuring Local SPAN](#), on page 1139

## Remote SPAN

RSPAN supports source ports, source VLANs, and destination ports on different devices (or different device stacks), enabling remote monitoring of multiple devices across your network.

**Figure 86: Example of RSPAN Configuration**

The figure below shows source ports on Device A and Device B. The traffic for each RSPAN session is carried over a user-specified RSPAN VLAN that is dedicated for that RSPAN session in all participating devices. The RSPAN traffic from the source ports or VLANs is copied into the RSPAN VLAN and forwarded over trunk ports carrying the RSPAN VLAN to a destination session monitoring the RSPAN VLAN. Each RSPAN source device must have either ports or VLANs as RSPAN sources. The destination is always a physical port,



as shown on Device C in the figure.

### Related Topics

[Creating an RSPAN Source Session](#), on page 1124

[Creating an RSPAN Destination Session](#), on page 1128

[Creating an RSPAN Destination Session and Configuring Incoming Traffic](#), on page 1130

[Examples: Creating an RSPAN VLAN](#), on page 1140

## SPAN and RSPAN Concepts and Terminology

### SPAN Sessions

SPAN sessions (local or remote) allow you to monitor traffic on one or more ports, or one or more VLANs, and send the monitored traffic to one or more destination ports.

A local SPAN session is an association of a destination port with source ports or source VLANs, all on a single network device. Local SPAN does not have separate source and destination sessions. Local SPAN sessions gather a set of ingress and egress packets specified by the user and form them into a stream of SPAN data, which is directed to the destination port.

RSPAN consists of at least one RSPAN source session, an RSPAN VLAN, and at least one RSPAN destination session. You separately configure RSPAN source sessions and RSPAN destination sessions on different network devices. To configure an RSPAN source session on a device, you associate a set of source ports or source VLANs with an RSPAN VLAN. The output of this session is the stream of SPAN packets that are sent to the RSPAN VLAN. To configure an RSPAN destination session on another device, you associate the destination port with the RSPAN VLAN. The destination session collects all RSPAN VLAN traffic and sends it out the RSPAN destination port.

An RSPAN source session is very similar to a local SPAN session, except for where the packet stream is directed. In an RSPAN source session, SPAN packets are relabeled with the RSPAN VLAN ID and directed over normal trunk ports to the destination device.

An RSPAN destination session takes all packets received on the RSPAN VLAN, strips off the VLAN tagging, and presents them on the destination port. The session presents a copy of all RSPAN VLAN packets (except Layer 2 control packets) to the user for analysis.

A single RSPAN session with multiple source and destination ports can be in the same session but more than one source session with the source being the same remote vlan is not allowed.

Traffic monitoring in a SPAN session has these restrictions:

- Sources can be ports or VLANs, but you cannot mix source ports and source VLANs in the same session.
- You can run both a local SPAN and an RSPAN source session in the same device or device stack. The device or device stack supports a total of 66 source and RSPAN destination sessions.
- You can configure two separate SPAN or RSPAN source sessions with separate or overlapping sets of SPAN source ports and VLANs. Both switched and routed ports can be configured as SPAN sources and destinations.
- You can have multiple destination ports in a SPAN session, but no more than 64 destination ports per device stack.
- SPAN sessions do not interfere with the normal operation of the device. However, an oversubscribed SPAN destination, for example, a 10-Mb/s port monitoring a 100-Mb/s port, can result in dropped or lost packets.
- When SPAN or RSPAN is enabled, each packet being monitored is sent twice, once as normal traffic and once as a monitored packet. Therefore monitoring a large number of ports or VLANs could potentially generate large amounts of network traffic.
- You can configure SPAN sessions on disabled ports; however, a SPAN session does not become active unless you enable the destination port and at least one source port or VLAN for that session.
- The device does not support a combination of local SPAN and RSPAN in a single session.

- An RSPAN source session cannot have a local destination port.
- An RSPAN destination session cannot have a local source port.
- An RSPAN destination session and an RSPAN source session that are using the same RSPAN VLAN cannot run on the same device or device stack.

### Related Topics

[Creating a Local SPAN Session](#), on page 1116

[Creating a Local SPAN Session and Configuring Incoming Traffic](#), on page 1119

[Example: Configuring Local SPAN](#), on page 1139

## Monitored Traffic

SPAN sessions can monitor these traffic types:

- Receive (Rx) SPAN—Receive (or ingress) SPAN monitors as much as possible all of the packets received by the source interface or VLAN before any modification or processing is performed by the device. A copy of each packet received by the source is sent to the destination port for that SPAN session.

Packets that are modified because of routing or Quality of Service (QoS)—for example, modified Differentiated Services Code Point (DSCP)—are copied before modification.

Features that can cause a packet to be dropped during receive processing have no effect on ingress SPAN; the destination port receives a copy of the packet even if the actual incoming packet is dropped. These features include IP standard and extended input Access Control Lists (ACLs), ingress QoS policing, VLAN ACLs, and egress QoS policing.

- Transmit (Tx) SPAN—Transmit (or egress) SPAN monitors as much as possible all of the packets sent by the source interface after all modification and processing is performed by the device. A copy of each packet sent by the source is sent to the destination port for that SPAN session. The copy is provided after the packet is modified.

Packets that are modified because of routing (for example, with modified time-to-live (TTL), MAC address, or QoS values) are duplicated (with the modifications) at the destination port.

Features that can cause a packet to be dropped during transmit processing also affect the duplicated copy for SPAN. These features include IP standard and extended output ACLs and egress QoS policing.

- Both—In a SPAN session, you can also monitor a port or VLAN for both received and sent packets. This is the default.

The default configuration for local SPAN session ports is to send all packets untagged. However, when you enter the **encapsulation replicate** keywords while configuring a destination port, these changes occur:

- Packets are sent on the destination port with the same encapsulation (untagged or IEEE 802.1Q) that they had on the source port.
- Packets of all types, including BPDU and Layer 2 protocol packets, are monitored.

Therefore, a local SPAN session with encapsulation replicate enabled can have a mixture of untagged and IEEE 802.1Q tagged packets appear on the destination port.

Device congestion can cause packets to be dropped at ingress source ports, egress source ports, or SPAN destination ports. In general, these characteristics are independent of one another. For example:

- A packet might be forwarded normally but dropped from monitoring due to an oversubscribed SPAN destination port.
- An ingress packet might be dropped from normal forwarding, but still appear on the SPAN destination port.
- An egress packet dropped because of device congestion is also dropped from egress SPAN.

In some SPAN configurations, multiple copies of the same source packet are sent to the SPAN destination port. For example, a bidirectional (both Rx and Tx) SPAN session is configured for the Rx monitor on port A and Tx monitor on port B. If a packet enters the device through port A and is switched to port B, both incoming and outgoing packets are sent to the destination port. Both packets are the same unless a Layer 3 rewrite occurs, in which case the packets are different because of the packet modification.

## Source Ports

A source port (also called a monitored port) is a switched or routed port that you monitor for network traffic analysis.

In a local SPAN session or RSPAN source session, you can monitor source ports or VLANs for traffic in one or both directions.

The device supports any number of source ports (up to the maximum number of available ports on the device) and any number of source VLANs (up to the maximum number of VLANs supported).

You cannot mix ports and VLANs in a single session.

A source port has these characteristics:

- It can be monitored in multiple SPAN sessions.
- Each source port can be configured with a direction (ingress, egress, or both) to monitor.
- It can be any port type (for example, EtherChannel, Gigabit Ethernet, and so forth).
- For EtherChannel sources, you can monitor traffic for the entire EtherChannel or individually on a physical port as it participates in the port channel.
- It can be an access port, trunk port, routed port, or voice VLAN port.
- It cannot be a destination port.
- Source ports can be in the same or different VLANs.
- You can monitor multiple source ports in a single session.

## Source VLANs

VLAN-based SPAN (VSPAN) is the monitoring of the network traffic in one or more VLANs. The SPAN or RSPAN source interface in VSPAN is a VLAN ID, and traffic is monitored on all the ports for that VLAN.

VSPAN has these characteristics:

- All active ports in the source VLAN are included as source ports and can be monitored in either or both directions.
- On a given port, only traffic on the monitored VLAN is sent to the destination port.
- If a destination port belongs to a source VLAN, it is excluded from the source list and is not monitored.

- If ports are added to or removed from the source VLANs, the traffic on the source VLAN received by those ports is added to or removed from the sources being monitored.
- You cannot use filter VLANs in the same session with VLAN sources.
- You can monitor only Ethernet VLANs.

## VLAN Filtering

When you monitor a trunk port as a source port, by default, all VLANs active on the trunk are monitored. You can limit SPAN traffic monitoring on trunk source ports to specific VLANs by using VLAN filtering.

- VLAN filtering applies only to trunk ports or to voice VLAN ports.
- VLAN filtering applies only to port-based sessions and is not allowed in sessions with VLAN sources.
- When a VLAN filter list is specified, only those VLANs in the list are monitored on trunk ports or on voice VLAN access ports.
- SPAN traffic coming from other port types is not affected by VLAN filtering; that is, all VLANs are allowed on other ports.
- VLAN filtering affects only traffic forwarded to the destination SPAN port and does not affect the switching of normal traffic.

## Destination Port

Each local SPAN session or RSPAN destination session must have a destination port (also called a monitoring port) that receives a copy of traffic from the source ports or VLANs and sends the SPAN packets to the user, usually a network analyzer.

A destination port has these characteristics:

- For a local SPAN session, the destination port must reside on the same device or device stack as the source port. For an RSPAN session, it is located on the device containing the RSPAN destination session. There is no destination port on a device or device stack running only an RSPAN source session.
- When a port is configured as a SPAN destination port, the configuration overwrites the original port configuration. When the SPAN destination configuration is removed, the port reverts to its previous configuration. If a configuration change is made to the port while it is acting as a SPAN destination port, the change does not take effect until the SPAN destination configuration had been removed.



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**Note** When QoS is configured on the SPAN destination port, QoS takes effect immediately.

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- If the port was in an EtherChannel group, it is removed from the group while it is a destination port. If it was a routed port, it is no longer a routed port.
- It can be any Ethernet physical port.
- It cannot be a secure port.
- It cannot be a source port.
- It can be an EtherChannel group (**ON** mode only).

- It cannot be a VLAN.
- It can participate in only one SPAN session at a time (a destination port in one SPAN session cannot be a destination port for a second SPAN session).
- When it is active, incoming traffic is disabled. The port does not transmit any traffic except that required for the SPAN session. Incoming traffic is never learned or forwarded on a destination port.
- If ingress traffic forwarding is enabled for a network security device, the destination port forwards traffic at Layer 2.
- It does not participate in any of the Layer 2 protocols (STP, VTP, CDP, DTP, PagP).
- A destination port that belongs to a source VLAN of any SPAN session is excluded from the source list and is not monitored.
- The maximum number of destination ports in a device or device stack is 64.

Local SPAN and RSPAN destination ports function differently with VLAN tagging and encapsulation:

- For local SPAN, if the **encapsulation replicate** keywords are specified for the destination port, these packets appear with the original encapsulation (untagged, ISL, or IEEE 802.1Q). If these keywords are not specified, packets appear in the untagged format. Therefore, the output of a local SPAN session with **encapsulation replicate** enabled can contain a mixture of untagged, ISL, or IEEE 802.1Q-tagged packets.
- For RSPAN, the original VLAN ID is lost because it is overwritten by the RSPAN VLAN identification. Therefore, all packets appear on the destination port as untagged.

## RSPAN VLAN

The RSPAN VLAN carries SPAN traffic between RSPAN source and destination sessions. RSPAN VLAN has these special characteristics:

- All traffic in the RSPAN VLAN is always flooded.
- No MAC address learning occurs on the RSPAN VLAN.
- RSPAN VLAN traffic only flows on trunk ports.
- RSPAN VLANs must be configured in VLAN configuration mode by using the **remote-span** VLAN configuration mode command.
- STP can run on RSPAN VLAN trunks but not on SPAN destination ports.
- An RSPAN VLAN cannot be a private-VLAN primary or secondary VLAN.

For VLANs 1 to 1005 that are visible to VLAN Trunking Protocol (VTP), the VLAN ID and its associated RSPAN characteristic are propagated by VTP. If you assign an RSPAN VLAN ID in the extended VLAN range (1006 to 4094), you must manually configure all intermediate devices.

It is normal to have multiple RSPAN VLANs in a network at the same time with each RSPAN VLAN defining a network-wide RSPAN session. That is, multiple RSPAN source sessions anywhere in the network can contribute packets to the RSPAN session. It is also possible to have multiple RSPAN destination sessions throughout the network, monitoring the same RSPAN VLAN and presenting traffic to the user. The RSPAN VLAN ID separates the sessions.

### Related Topics

[Creating an RSPAN Source Session](#), on page 1124

[Creating an RSPAN Destination Session](#), on page 1128

[Creating an RSPAN Destination Session and Configuring Incoming Traffic](#), on page 1130

[Examples: Creating an RSPAN VLAN](#), on page 1140

## SPAN and RSPAN Interaction with Other Features

SPAN interacts with these features:

- **Routing**—SPAN does not monitor routed traffic. VSPAN only monitors traffic that enters or exits the device, not traffic that is routed between VLANs. For example, if a VLAN is being Rx-monitored and the device routes traffic from another VLAN to the monitored VLAN, that traffic is not monitored and not received on the SPAN destination port.
- **STP**—A destination port does not participate in STP while its SPAN or RSPAN session is active. The destination port can participate in STP after the SPAN or RSPAN session is disabled. On a source port, SPAN does not affect the STP status. STP can be active on trunk ports carrying an RSPAN VLAN.
- **CDP**—A SPAN destination port does not participate in CDP while the SPAN session is active. After the SPAN session is disabled, the port again participates in CDP.
- **VTP**—You can use VTP to prune an RSPAN VLAN between devices.
- **VLAN and trunking**—You can modify VLAN membership or trunk settings for source or destination ports at any time. However, changes in VLAN membership or trunk settings for a destination port do not take effect until you remove the SPAN destination configuration. Changes in VLAN membership or trunk settings for a source port immediately take effect, and the respective SPAN sessions automatically adjust accordingly.
- **EtherChannel**—You can configure an EtherChannel group as a source port or a SPAN destination port. When a group is configured as a SPAN source, the entire group is monitored.

If a physical port is added to a monitored EtherChannel group, the new port is added to the SPAN source port list. If a port is removed from a monitored EtherChannel group, it is automatically removed from the source port list.

A physical port that belongs to an EtherChannel group can be configured as a SPAN source port and still be a part of the EtherChannel. In this case, data from the physical port is monitored as it participates in the EtherChannel. However, if a physical port that belongs to an EtherChannel group is configured as a SPAN destination, it is removed from the group. After the port is removed from the SPAN session, it rejoins the EtherChannel group. Ports removed from an EtherChannel group remain members of the group, but they are in the inactive or suspended state.

If a physical port that belongs to an EtherChannel group is a destination port and the EtherChannel group is a source, the port is removed from the EtherChannel group and from the list of monitored ports.

- **Multicast traffic** can be monitored. For egress and ingress port monitoring, only a single unedited packet is sent to the SPAN destination port. It does not reflect the number of times the multicast packet is sent.
- A **private-VLAN** port cannot be a SPAN destination port.
- A **secure** port cannot be a SPAN destination port.

For SPAN sessions, do not enable port security on ports with monitored egress when ingress forwarding is enabled on the destination port. For RSPAN source sessions, do not enable port security on any ports with monitored egress.

- An IEEE 802.1x port can be a SPAN source port. You can enable IEEE 802.1x on a port that is a SPAN destination port; however, IEEE 802.1x is disabled until the port is removed as a SPAN destination.

For SPAN sessions, do not enable IEEE 802.1x on ports with monitored egress when ingress forwarding is enabled on the destination port. For RSPAN source sessions, do not enable IEEE 802.1x on any ports that are egress monitored.

## SPAN and RSPAN and Device Stacks

Because the stack of devices represents one logical device, local SPAN source ports and destination ports can be in different devices in the stack. Therefore, the addition or deletion of devices in the stack can affect a local SPAN session, as well as an RSPAN source or destination session. An active session can become inactive when a device is removed from the stack or an inactive session can become active when a device is added to the stack.

## Flow-Based SPAN

You can control the type of network traffic to be monitored in SPAN or RSPAN sessions by using flow-based SPAN (FSPAN) or flow-based RSPAN (FRSPAN), which apply access control lists (ACLs) to the monitored traffic on the source ports. The FSPAN ACLs can be configured to filter IPv4, IPv6, and non-IP monitored traffic.

You apply an ACL to a SPAN session through the interface. It is applied to all the traffic that is monitored on all interfaces in the SPAN session. The packets that are permitted by this ACL are copied to the SPAN destination port. No other packets are copied to the SPAN destination port.

The original traffic continues to be forwarded, and any port, VLAN, and router ACLs attached are applied. The FSPAN ACL does not have any effect on the forwarding decisions. Similarly, the port, VLAN, and router ACLs do not have any effect on the traffic monitoring. If a security input ACL denies a packet and it is not forwarded, the packet is still copied to the SPAN destination ports if the FSPAN ACL permits it. But if the security output ACL denies a packet and it is not sent, it is not copied to the SPAN destination ports. However, if the security output ACL permits the packet to go out, it is only copied to the SPAN destination ports if the FSPAN ACL permits it. This is also true for an RSPAN session.

You can attach three types of FSPAN ACLs to the SPAN session:

- IPv4 FSPAN ACL— Filters only IPv4 packets.
- IPv6 FSPAN ACL— Filters only IPv6 packets.
- MAC FSPAN ACL— Filters only non-IP packets.

If a VLAN-based FSPAN session configured on a stack cannot fit in the hardware memory on one or more devices, it is treated as unloaded on those devices, and traffic meant for the FSPAN ACL and sourcing on that device is not copied to the SPAN destination ports. The FSPAN ACL continues to be correctly applied, and traffic is copied to the SPAN destination ports on the devices where the FSPAN ACL fits in the hardware memory.

When an empty FSPAN ACL is attached, some hardware functions copy all traffic to the SPAN destination ports for that ACL. If sufficient hardware resources are not available, even an empty FSPAN ACL can be unloaded.

IPv4 and MAC FSPAN ACLs are supported on all feature sets. IPv6 FSPAN ACLs are supported only in the advanced IP Services feature set.



**Related Topics**

[Configuring an FSPAN Session](#), on page 1133

[Configuring an FRSPAN Session](#), on page 1135

## Default SPAN and RSPAN Configuration

*Table 77: Default SPAN and RSPAN Configuration*

Feature	Default Setting
SPAN state (SPAN and RSPAN)	Disabled.
Source port traffic to monitor	Both received and sent traffic ( <b>both</b> ).
Encapsulation type (destination port)	Native form (untagged packets).
Ingress forwarding (destination port)	Disabled.
VLAN filtering	On a trunk interface used as a source port, all VLANs are monitored.
RSPAN VLANs	None configured.

## Configuration Guidelines

### SPAN Configuration Guidelines

- To remove a source or destination port or VLAN from the SPAN session, use the **no monitor session session\_number source {interface interface-id | vlan vlan-id}** global configuration command or the **monitor session session\_number destination interface interface-id** global configuration command. For destination interfaces, the **encapsulation** options are ignored with the **no** form of the command.
- To monitor all VLANs on the trunk port, use the **no monitor session session\_number filter** global configuration command.

**Related Topics**

[Creating a Local SPAN Session](#), on page 1116

[Creating a Local SPAN Session and Configuring Incoming Traffic](#), on page 1119

[Example: Configuring Local SPAN](#), on page 1139

### RSPAN Configuration Guidelines

- All the SPAN configuration guidelines apply to RSPAN.
- As RSPAN VLANs have special properties, you should reserve a few VLANs across your network for use as RSPAN VLANs; do not assign access ports to these VLANs.
- You can apply an output ACL to RSPAN traffic to selectively filter or monitor specific packets. Specify these ACLs on the RSPAN VLAN in the RSPAN source devices.

- For RSPAN configuration, you can distribute the source ports and the destination ports across multiple devices in your network.
- Access ports (including voice VLAN ports) on the RSPAN VLAN are put in the inactive state.
- You can configure any VLAN as an RSPAN VLAN as long as these conditions are met:
  - The same RSPAN VLAN is used for an RSPAN session in all the devices.
  - All participating devices support RSPAN.

### Related Topics

[Creating an RSPAN Source Session](#), on page 1124

[Creating an RSPAN Destination Session](#), on page 1128

[Creating an RSPAN Destination Session and Configuring Incoming Traffic](#), on page 1130

[Examples: Creating an RSPAN VLAN](#), on page 1140

## FSPAN and FRSPAN Configuration Guidelines

- FSPAN is not supported on LAN base.
- When at least one FSPAN ACL is attached, FSPAN is enabled.
- When you attach at least one FSPAN ACL that is not empty to a SPAN session, and you have not attached one or more of the other FSPAN ACLs (for instance, you have attached an IPv4 ACL that is not empty, and have not attached IPv6 and MAC ACLs), FSPAN blocks the traffic that would have been filtered by the unattached ACLs. Therefore, this traffic is not monitored.

### Related Topics

[Configuring an FSPAN Session](#), on page 1133

[Configuring an FRSPAN Session](#), on page 1135

# How to Configure SPAN and RSPAN

## Creating a Local SPAN Session

Follow these steps to create a SPAN session and specify the source (monitored) ports or VLANs and the destination (monitoring) ports.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<p><b>no monitor session</b> {<i>session_number</i>   <b>all</b>   <b>local</b>   <b>remote</b>}</p> <p><b>Example:</b></p> <pre>Device(config)# no monitor session all</pre>	<p>Removes any existing SPAN configuration for the session.</p> <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 4.</li> <li>• <b>all</b>—Removes all SPAN sessions.</li> <li>• <b>local</b>—Removes all local sessions.</li> <li>• <b>remote</b>—Removes all remote SPAN sessions.</li> </ul>
<b>Step 4</b>	<p><b>monitor session</b> <i>session_number</i> <b>source</b> {<b>interface</b> <i>interface-id</i>   <b>vlan</b> <i>vlan-id</i>} [,   -] [<b>both</b>   <b>rx</b>   <b>tx</b>]</p> <p><b>Example:</b></p> <pre>Device(config)# monitor session 1 source interface gigabitethernet1/0/1</pre>	<p>Specifies the SPAN session and the source port (monitored port).</p> <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 4.</li> <li>• For <i>interface-id</i>, specify the source port to monitor. Valid interfaces include physical interfaces and port-channel logical interfaces (<b>port-channel</b> <i>port-channel-number</i>). Valid port-channel numbers are 1 to 6.</li> <li>• For <i>vlan-id</i>, specify the source VLAN to monitor. The range is 1 to 4094 (excluding the RSPAN VLAN).</li> </ul> <p><b>Note</b> A single session can include multiple sources (ports or VLANs) defined in a series of commands, but you cannot combine source ports and source VLANs in one session.</p> <ul style="list-style-type: none"> <li>• (Optional) [,   -] Specifies a series or range of interfaces. Enter a space before and after the comma; enter a space before and after the hyphen.</li> <li>• (Optional) <b>both</b>   <b>rx</b>   <b>tx</b>—Specifies the direction of traffic to monitor. If you do not specify a traffic direction, the source interface sends both sent and received traffic.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>both</b>—Monitors both received and sent traffic.</li> <li>• <b>rx</b>—Monitors received traffic.</li> <li>• <b>tx</b>—Monitors sent traffic.</li> </ul> <p><b>Note</b> You can use the <b>monitor session <i>session_number</i> source</b> command multiple times to configure multiple source ports.</p>
<b>Step 5</b>	<p><b>monitor session <i>session_number</i> destination {interface <i>interface-id</i> [, -] [encapsulation replicate]}</b></p> <p><b>Example:</b></p> <pre>Device(config)# monitor session 1 destination interface gigabitethernet1/0/2 encapsulation replicate</pre>	<p>Specifies the SPAN session and the destination port (monitoring port). The port LED changes to amber when the configuration changes take effect. The LED returns to its original state(green) only after removing the SPAN destination configuration.</p> <p><b>Note</b> For local SPAN, you must use the same session number for the source and destination interfaces.</p> <ul style="list-style-type: none"> <li>• For <i>session_number</i>, specify the session number entered in step 4.</li> <li>• For <i>interface-id</i>, specify the destination port. The destination interface must be a physical port; it cannot be an EtherChannel, and it cannot be a VLAN.</li> <li>• (Optional) [, -] Specifies a series or range of interfaces. Enter a space before and after the comma; enter a space before and after the hyphen.</li> </ul> <p>(Optional) <b>encapsulation replicate</b> specifies that the destination interface replicates the source interface encapsulation method. If not selected, the default is to send packets in native form (untagged).</p> <p><b>Note</b> You can use <b>monitor session <i>session_number</i> destination</b> command multiple times to configure multiple destination ports.</p>
<b>Step 6</b>	<p><b>end</b></p> <p><b>Example:</b></p>	<p>Returns to privileged EXEC mode.</p>

	Command or Action	Purpose
	Device(config)# <b>end</b>	
<b>Step 7</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Local SPAN](#), on page 1106

[SPAN Sessions](#), on page 1108

[SPAN Configuration Guidelines](#), on page 1115

## Creating a Local SPAN Session and Configuring Incoming Traffic

Follow these steps to create a SPAN session, to specify the source ports or VLANs and the destination ports, and to enable incoming traffic on the destination port for a network security device (such as a Cisco IDS Sensor Appliance).

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>no monitor session</b> { <i>session_number</i>   <b>all</b>   <b>local</b>   <b>remote</b> } <b>Example:</b> Device(config)# <b>no monitor session all</b>	Removes any existing SPAN configuration for the session. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 4.</li> <li>• <b>all</b>—Removes all SPAN sessions.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>local</b>—Removes all local sessions.</li> <li>• <b>remote</b>—Removes all remote SPAN sessions.</li> </ul>
<b>Step 4</b>	<p><b>monitor session</b> <i>session_number</i> <b>source</b> {<b>interface</b> <i>interface-id</i>   <b>vlan</b> <i>vlan-id</i>} [,   -] [<b>both</b>   <b>rx</b>   <b>tx</b>]</p> <p><b>Example:</b></p> <pre>Device(config)# monitor session 2 source gigabitethernet0/1 rx</pre>	Specifies the SPAN session and the source port (monitored port).
<b>Step 5</b>	<p><b>monitor session</b> <i>session_number</i> <b>destination</b> {<b>interface</b> <i>interface-id</i> [,   -] [<b>encapsulation replicate</b>[<b>ingress</b> {<b>dot1q</b> <i>vlan</i> <i>vlan-id</i>   <b>untagged</b> <i>vlan</i> <i>vlan-id</i>   <b>vlan</b> <i>vlan-id</i>}]}</p> <p><b>Example:</b></p> <pre>Device(config)# monitor session 2 destination interface gigabitethernet1/0/2 encapsulation replicate ingress dot1q vlan 6</pre>	<p>Specifies the SPAN session, the destination port, the packet encapsulation, and the ingress VLAN and encapsulation.</p> <ul style="list-style-type: none"> <li>• For <i>session_number</i>, specify the session number entered in Step 4.</li> <li>• For <i>interface-id</i>, specify the destination port. The destination interface must be a physical port; it cannot be an EtherChannel, and it cannot be a VLAN.</li> <li>• (Optional) [,   -]—Specifies a series or range of interfaces. Enter a space before and after the comma or hyphen.</li> <li>• (Optional) <b>encapsulation replicate</b>—Specifies that the destination interface replicates the source interface encapsulation method. If not selected, the default is to send packets in native form (untagged).</li> <li>• <b>ingress</b>—Enables forwarding of incoming traffic on the destination port and to specify the encapsulation type. <ul style="list-style-type: none"> <li>• <b>dot1q</b> <i>vlan</i> <i>vlan-id</i>—Accepts incoming packets with IEEE 802.1Q encapsulation with the specified VLAN as the default VLAN.</li> <li>• <b>untagged</b> <i>vlan</i> <i>vlan-id</i> or <b>vlan</b> <i>vlan-id</i>—Accepts incoming packets with untagged encapsulation type with the specified VLAN as the default VLAN.</li> </ul> </li> </ul>

	Command or Action	Purpose
<b>Step 6</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show running-config</b> <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Local SPAN](#), on page 1106

[SPAN Sessions](#), on page 1108

[SPAN Configuration Guidelines](#), on page 1115

[Example: Configuring Local SPAN](#), on page 1139

## Specifying VLANs to Filter

Follow these steps to limit SPAN source traffic to specific VLANs.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>no monitor session</b> { <i>session_number</i>   <b>all</b>   <b>local</b>   <b>remote</b> }	Removes any existing SPAN configuration for the session.

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config)# no monitor session all</pre>	<ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 66.</li> <li>• <b>all</b>—Removes all SPAN sessions.</li> <li>• <b>local</b>—Removes all local sessions.</li> <li>• <b>remote</b>—Removes all remote SPAN sessions.</li> </ul>
<b>Step 4</b>	<p><b>monitor session</b> <i>session_number</i> <b>source interface</b> <i>interface-id</i></p> <p><b>Example:</b></p> <pre>Device(config)# monitor session 2 source interface gigabitethernet1/0/2 rx</pre>	<p>Specifies the characteristics of the source port (monitored port) and SPAN session.</p> <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 66.</li> <li>• For <i>interface-id</i>, specify the source port to monitor. The interface specified must already be configured as a trunk port.</li> </ul>
<b>Step 5</b>	<p><b>monitor session</b> <i>session_number</i> <b>filter vlan</b> <i>vlan-id</i> [,   -]</p> <p><b>Example:</b></p> <pre>Device(config)# monitor session 2 filter vlan 1 - 5 , 9</pre>	<p>Limits the SPAN source traffic to specific VLANs.</p> <ul style="list-style-type: none"> <li>• For <i>session_number</i>, enter the session number specified in Step 4.</li> <li>• For <i>vlan-id</i>, the range is 1 to 4094.</li> <li>• (Optional) Use a comma (,) to specify a series of VLANs, or use a hyphen (-) to specify a range of VLANs. Enter a space before and after the comma; enter a space before and after the hyphen.</li> </ul>
<b>Step 6</b>	<p><b>monitor session</b> <i>session_number</i> <b>destination</b> {<b>interface</b> <i>interface-id</i> [,   -] [<b>encapsulation replicate</b>]}</p> <p><b>Example:</b></p> <pre>Device(config)# monitor session 2 destination interface gigabitethernet1/0/1</pre>	<p>Specifies the SPAN session and the destination port (monitoring port).</p> <ul style="list-style-type: none"> <li>• For <i>session_number</i>, specify the session number entered in Step 4.</li> <li>• For <i>interface-id</i>, specify the destination port. The destination interface must be a physical port; it cannot be an EtherChannel, and it cannot be a VLAN.</li> <li>• (Optional) [,   -] Specifies a series or range of interfaces. Enter a space before and after the comma; enter a space before and after the hyphen.</li> <li>• (Optional) <b>encapsulation replicate</b> specifies that the destination interface replicates the source interface encapsulation method. If not selected, the default is to send packets in native form (untagged).</li> </ul>



	Command or Action	Purpose
<b>Step 7</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring a VLAN as an RSPAN VLAN

Follow these steps to create a new VLAN, then configure it to be the RSPAN VLAN for the RSPAN session.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>vlan <i>vlan-id</i></b> <b>Example:</b> <pre>Device(config)# vlan 100</pre>	Enters a VLAN ID to create a VLAN, or enters the VLAN ID of an existing VLAN, and enters VLAN configuration mode. The range is 2 to 1001 and 1006 to 4094.  The RSPAN VLAN cannot be VLAN 1 (the default VLAN) or VLAN IDs 1002 through 1005 (reserved for Token Ring and FDDI VLANs).

	Command or Action	Purpose
<b>Step 4</b>	<b>remote-span</b> <b>Example:</b> Device (config-vlan) # <b>remote-span</b>	Configures the VLAN as an RSPAN VLAN.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device (config-vlan) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

### What to do next

You must create the RSPAN VLAN in all devices that will participate in RSPAN. If the RSPAN VLAN-ID is in the normal range (lower than 1005) and VTP is enabled in the network, you can create the RSPAN VLAN in one device, and VTP propagates it to the other devices in the VTP domain. For extended-range VLANs (greater than 1005), you must configure RSPAN VLAN on both source and destination devices and any intermediate devices.

Use VTP pruning to get an efficient flow of RSPAN traffic, or manually delete the RSPAN VLAN from all trunks that do not need to carry the RSPAN traffic.

To remove the remote SPAN characteristic from a VLAN and convert it back to a normal VLAN, use the **no remote-span** VLAN configuration command.

To remove a source port or VLAN from the SPAN session, use the **no monitor session session\_number source {interface interface-id | vlan vlan-id}** global configuration command. To remove the RSPAN VLAN from the session, use the **no monitor session session\_number destination remote vlan vlan-id**.

## Creating an RSPAN Source Session

Follow these steps to create and start an RSPAN source session and to specify the monitored source and the destination RSPAN VLAN.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>no monitor session</b> { <i>session_number</i>   <b>all</b>   <b>local</b>   <b>remote</b> } <b>Example:</b> <pre>Device(config)# no monitor session 1</pre>	Removes any existing SPAN configuration for the session. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 66.</li> <li>• <b>all</b>—Removes all SPAN sessions.</li> <li>• <b>local</b>—Removes all local sessions.</li> <li>• <b>remote</b>—Removes all remote SPAN sessions.</li> </ul>
<b>Step 4</b>	<b>monitor session</b> <i>session_number</i> <b>source</b> { <b>interface</b> <i>interface-id</i>   <b>vlan</b> <i>vlan-id</i> } [,   -] [ <b>both</b>   <b>rx</b>   <b>tx</b> ] <b>Example:</b> <pre>Device(config)# monitor session 1 source interface gigabitethernet1/0/1 tx</pre>	Specifies the RSPAN session and the source port (monitored port). <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 66.</li> <li>• Enter a source port or source VLAN for the RSPAN session:               <ul style="list-style-type: none"> <li>• For <i>interface-id</i>, specifies the source port to monitor. Valid interfaces include physical interfaces and port-channel logical interfaces (<b>port-channel</b> <i>port-channel-number</i>). Valid port-channel numbers are 1 to 48.</li> <li>• For <i>vlan-id</i>, specifies the source VLAN to monitor. The range is 1 to 4094 (excluding the RSPAN VLAN).</li> </ul> </li> </ul> A single session can include multiple sources (ports or VLANs), defined in a series of commands, but you cannot combine source ports and source VLANs in one session.

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• (Optional) [,   -]—Specifies a series or range of interfaces. Enter a space before and after the comma; enter a space before and after the hyphen.</li> <li>• (Optional) <b>both</b>   <b>rx</b>   <b>tx</b>—Specifies the direction of traffic to monitor. If you do not specify a traffic direction, the source interface sends both sent and received traffic. <ul style="list-style-type: none"> <li>• <b>both</b>—Monitors both received and sent traffic.</li> <li>• <b>rx</b>—Monitors received traffic.</li> <li>• <b>tx</b>—Monitors sent traffic.</li> </ul> </li> </ul>
<b>Step 5</b>	<b>monitor session</b> <i>session_number</i> <b>destination</b> <b>remote vlan</b> <i>vlan-id</i> <b>Example:</b> <pre>Device(config)# monitor session 1 destination remote vlan 100</pre>	Specifies the RSPAN session, the destination RSPAN VLAN, and the destination-port group. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, enter the number defined in Step 4.</li> <li>• For <i>vlan-id</i>, specify the source RSPAN VLAN to monitor.</li> </ul>
<b>Step 6</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Remote SPAN](#), on page 1107

[RSPAN VLAN](#), on page 1112

[RSPAN Configuration Guidelines](#), on page 1115

## Specifying VLANs to Filter

Follow these steps to configure the RSPAN source session to limit RSPAN source traffic to specific VLANs.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>no monitor session</b> { <i>session_number</i>   <b>all</b>   <b>local</b>   <b>remote</b> } <b>Example:</b> Device(config)# <b>no monitor session 2</b>	Removes any existing SPAN configuration for the session. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 66.</li> <li>• <b>all</b>—Removes all SPAN sessions.</li> <li>• <b>local</b>—Removes all local sessions.</li> <li>• <b>remote</b>—Removes all remote SPAN sessions.</li> </ul>
<b>Step 4</b>	<b>monitor session</b> <i>session_number</i> <b>source</b> <b>interface</b> <i>interface-id</i> <b>Example:</b> Device(config)# <b>monitor session 2 source</b> <b>interface gigabitethernet1/0/2 rx</b>	Specifies the characteristics of the source port (monitored port) and SPAN session. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 66.</li> <li>• For <i>interface-id</i>, specify the source port to monitor. The interface specified must already be configured as a trunk port.</li> </ul>
<b>Step 5</b>	<b>monitor session</b> <i>session_number</i> <b>filter</b> <b>vlan</b> <i>vlan-id</i> [, -] <b>Example:</b> Device(config)# <b>monitor session 2 filter</b> <b>vlan 1 - 5 , 9</b>	Limits the SPAN source traffic to specific VLANs. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, enter the session number specified in step 4.</li> <li>• For <i>vlan-id</i>, the range is 1 to 4094.</li> <li>• (Optional) , - Use a comma (,) to specify a series of VLANs or use a hyphen (-) to specify a range of VLANs. Enter a space before and after the comma; enter a space before and after the hyphen.</li> </ul>

	Command or Action	Purpose
<b>Step 6</b>	<b>monitor session</b> <i>session_number</i> <b>destination</b> <b>remote vlan</b> <i>vlan-id</i> <b>Example:</b> <pre>Device(config)# monitor session 2 destination remote vlan 902</pre>	Specifies the RSPAN session and the destination remote VLAN (RSPAN VLAN). <ul style="list-style-type: none"> <li>For <i>session_number</i>, enter the session number specified in Step 4.</li> <li>For <i>vlan-id</i>, specify the RSPAN VLAN to carry the monitored traffic to the destination port.</li> </ul>
<b>Step 7</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Creating an RSPAN Destination Session

You configure an RSPAN destination session on a different device or device stack; that is, not the device or device stack on which the source session was configured.

Follow these steps to define the RSPAN VLAN on that device, to create an RSPAN destination session, and to specify the source RSPAN VLAN and the destination port.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <b>configure terminal</b>	
<b>Step 3</b>	<b>vlan <i>vlan-id</i></b> <b>Example:</b> Device (config)# <b>vlan 901</b>	Specifies the VLAN ID of the RSPAN VLAN created from the source device, and enters VLAN configuration mode.  If both devices are participating in VTP and the RSPAN VLAN ID is from 2 to 1005, Steps 3 through 5 are not required because the RSPAN VLAN ID is propagated through the VTP network.
<b>Step 4</b>	<b>remote-span</b> <b>Example:</b> Device (config-vlan)# <b>remote-span</b>	Identifies the VLAN as the RSPAN VLAN.
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device (config-vlan)# <b>exit</b>	Returns to global configuration mode.
<b>Step 6</b>	<b>no monitor session {<i>session_number</i>   all   local   remote}</b> <b>Example:</b> Device (config)# <b>no monitor session 1</b>	Removes any existing SPAN configuration for the session. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 66.</li> <li>• <b>all</b>—Removes all SPAN sessions.</li> <li>• <b>local</b>—Removes all local sessions.</li> <li>• <b>remote</b>—Removes all remote SPAN sessions.</li> </ul>
<b>Step 7</b>	<b>monitor session <i>session_number</i> source remote vlan <i>vlan-id</i></b> <b>Example:</b> Device (config)# <b>monitor session 1 source remote vlan 901</b>	Specifies the RSPAN session and the source RSPAN VLAN. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 66.</li> <li>• For <i>vlan-id</i>, specify the source RSPAN VLAN to monitor.</li> </ul>
<b>Step 8</b>	<b>monitor session <i>session_number</i> destination interface <i>interface-id</i></b> <b>Example:</b> Device (config)# <b>monitor session 1 destination interface gigabitethernet2/0/1</b>	Specifies the RSPAN session and the destination interface. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, enter the number defined in Step 7.</li> </ul> In an RSPAN destination session, you must use the same session number for the source RSPAN VLAN and the destination port.

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>For <i>interface-id</i>, specify the destination interface. The destination interface must be a physical interface.</li> <li>Though visible in the command-line help string, <b>encapsulation replicate</b> is not supported for RSPAN. The original VLAN ID is overwritten by the RSPAN VLAN ID, and all packets appear on the destination port as untagged.</li> </ul>
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device (config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 10</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Remote SPAN](#), on page 1107

[RSPAN VLAN](#), on page 1112

[RSPAN Configuration Guidelines](#), on page 1115

## Creating an RSPAN Destination Session and Configuring Incoming Traffic

Follow these steps to create an RSPAN destination session, to specify the source RSPAN VLAN and the destination port, and to enable incoming traffic on the destination port for a network security device (such as a Cisco IDS Sensor Appliance).

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>



	Command or Action	Purpose
	Device> <b>enable</b>	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>no monitor session</b> { <i>session_number</i>   <b>all</b>   <b>local</b>   <b>remote</b> } <b>Example:</b> Device(config)# <b>no monitor session 2</b>	Removes any existing SPAN configuration for the session. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 66.</li> <li>• <b>all</b>—Removes all SPAN sessions.</li> <li>• <b>local</b>—Removes all local sessions.</li> <li>• <b>remote</b>—Removes all remote SPAN sessions.</li> </ul>
<b>Step 4</b>	<b>monitor session</b> <i>session_number</i> <b>source remote vlan</b> <i>vlan-id</i> <b>Example:</b> Device(config)# <b>monitor session 2 source remote vlan 901</b>	Specifies the RSPAN session and the source RSPAN VLAN. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 66.</li> <li>• For <i>vlan-id</i>, specify the source RSPAN VLAN to monitor.</li> </ul>
<b>Step 5</b>	<b>monitor session</b> <i>session_number</i> <b>destination</b> { <b>interface</b> <i>interface-id</i> [,   -] [ <b>ingress</b> { <b>dot1q vlan</b> <i>vlan-id</i>   <b>untagged vlan</b> <i>vlan-id</i>   <b>vlan</b> <i>vlan-id</i> }]} <b>Example:</b> Device(config)# <b>monitor session 2 destination interface gigabitethernet1/0/2 ingress vlan 6</b>	Specifies the SPAN session, the destination port, the packet encapsulation, and the incoming VLAN and encapsulation. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, enter the number defined in Step 5.                In an RSPAN destination session, you must use the same session number for the source RSPAN VLAN and the destination port.</li> <li>• For <i>interface-id</i>, specify the destination interface. The destination interface must be a physical interface.</li> <li>• Though visible in the command-line help string, <b>encapsulation replicate</b> is not supported for RSPAN. The original VLAN ID is overwritten by the RSPAN VLAN ID, and all packets appear on the destination port as untagged.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• (Optional) [, -] Specifies a series or range of interfaces. Enter a space before and after the comma; enter a space before and after the hyphen.</li> <li>• Enter <b>ingress</b> with additional keywords to enable forwarding of incoming traffic on the destination port and to specify the encapsulation type: <ul style="list-style-type: none"> <li>• <b>dot1q vlan <i>vlan-id</i></b>—Forwards incoming packets with IEEE 802.1Q encapsulation with the specified VLAN as the default VLAN.</li> <li>• <b>untagged vlan <i>vlan-id</i> or vlan <i>vlan-id</i></b>—Forwards incoming packets with untagged encapsulation type with the specified VLAN as the default VLAN.</li> </ul> </li> </ul>
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Remote SPAN](#), on page 1107

[RSPAN VLAN](#), on page 1112

[RSPAN Configuration Guidelines](#), on page 1115

[Examples: Creating an RSPAN VLAN](#), on page 1140

## Configuring an FSPAN Session

Follow these steps to create a SPAN session, specify the source (monitored) ports or VLANs and the destination (monitoring) ports, and configure FSPAN for the session.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>no monitor session</b> { <i>session_number</i>   <b>all</b>   <b>local</b>   <b>remote</b> } <b>Example:</b> Device(config)# <b>no monitor session 2</b>	Removes any existing SPAN configuration for the session. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 66.</li> <li>• <b>all</b>—Removes all SPAN sessions.</li> <li>• <b>local</b>—Removes all local sessions.</li> <li>• <b>remote</b>—Removes all remote SPAN sessions.</li> </ul>
<b>Step 4</b>	<b>monitor session</b> <i>session_number</i> <b>source</b> { <b>interface</b> <i>interface-id</i>   <b>vlan</b> <i>vlan-id</i> } [,   -] [ <b>both</b>   <b>rx</b>   <b>tx</b> ] <b>Example:</b> Device(config)# <b>monitor session 2 source interface gigabitethernet1/0/1</b>	Specifies the SPAN session and the source port (monitored port). <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 66.</li> <li>• For <i>interface-id</i>, specifies the source port to monitor. Valid interfaces include physical interfaces and port-channel logical interfaces (<b>port-channel</b> <i>port-channel-number</i>). Valid port-channel numbers are 1 to 48.</li> <li>• For <i>vlan-id</i>, specify the source VLAN to monitor. The range is 1 to 4094 (excluding the RSPAN VLAN).</li> </ul> <p><b>Note</b> A single session can include multiple sources (ports or VLANs) defined in a series of commands, but you cannot combine source ports and source VLANs in one session.</p>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• (Optional) [,   -]—Specifies a series or range of interfaces. Enter a space before and after the comma; enter a space before and after the hyphen.</li> <li>• (Optional) [<b>both</b>   <b>rx</b>   <b>tx</b>]—Specifies the direction of traffic to monitor. If you do not specify a traffic direction, the SPAN monitors both sent and received traffic. <ul style="list-style-type: none"> <li>• <b>both</b>—Monitors both sent and received traffic. This is the default.</li> <li>• <b>rx</b>—Monitors received traffic.</li> <li>• <b>tx</b>—Monitors sent traffic.</li> </ul> </li> </ul> <p><b>Note</b> You can use the <b>monitor session session_number source</b> command multiple times to configure multiple source ports.</p>
<b>Step 5</b>	<p><b>monitor session session_number destination {interface interface-id [,   -] [encapsulation replicate]}</b></p> <p><b>Example:</b></p> <pre>Device(config)# monitor session 2 destination interface gigabitethernet1/0/2 encapsulation replicate</pre>	<p>Specifies the SPAN session and the destination port (monitoring port).</p> <ul style="list-style-type: none"> <li>• For <i>session_number</i>, specify the session number entered in Step 4.</li> <li>• For <b>destination</b>, specify the following parameters: <ul style="list-style-type: none"> <li>• For <i>interface-id</i>, specify the destination port. The destination interface must be a physical port; it cannot be an EtherChannel, and it cannot be a VLAN.</li> <li>• (Optional) [,   -] Specifies a series or range of interfaces. Enter a space before and after the comma; enter a space before and after the hyphen.</li> <li>• (Optional) <b>encapsulation replicate</b> specifies that the destination interface replicates the source interface encapsulation method. If not selected, the default is to send packets in native form (untagged).</li> </ul> </li> </ul>

	Command or Action	Purpose
		<p><b>Note</b> For local SPAN, you must use the same session number for the source and destination interfaces.</p> <p>You can use <b>monitor session <i>session_number</i> destination</b> command multiple times to configure multiple destination ports.</p>
<b>Step 6</b>	<p><b>monitor session <i>session_number</i> filter {ip   ipv6   mac} access-group {<i>access-list-number</i>   <i>name</i>}</b></p> <p><b>Example:</b></p> <pre>Device(config)# monitor session 2 filter ipv6 access-group 4</pre>	<p>Specifies the SPAN session, the types of packets to filter, and the ACLs to use in an FSPAN session.</p> <ul style="list-style-type: none"> <li>For <i>session_number</i>, specify the session number entered in Step 4.</li> <li>For <i>access-list-number</i>, specify the ACL number that you want to use to filter traffic.</li> <li>For <i>name</i>, specify the ACL name that you want to use to filter traffic.</li> </ul>
<b>Step 7</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 8</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 9</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Flow-Based SPAN](#), on page 1114

[FSPAN and FRSPAN Configuration Guidelines](#), on page 1116

## Configuring an FRSPAN Session

Follow these steps to start an RSPAN source session, specify the monitored source and the destination RSPAN VLAN, and configure FRSPAN for the session.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>no monitor session</b> { <i>session_number</i>   <b>all</b>   <b>local</b>   <b>remote</b> } <b>Example:</b> <pre>Device (config)# no monitor session 2</pre>	Removes any existing SPAN configuration for the session. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 66.</li> <li>• <b>all</b>—Removes all SPAN sessions.</li> <li>• <b>local</b>—Removes all local sessions.</li> <li>• <b>remote</b>—Removes all remote SPAN sessions.</li> </ul>
<b>Step 4</b>	<b>monitor session</b> <i>session_number</i> <b>source</b> { <b>interface</b> <i>interface-id</i>   <b>vlan</b> <i>vlan-id</i> } [,   -] [ <b>both</b>   <b>rx</b>   <b>tx</b> ] <b>Example:</b> <pre>Device (config)# monitor session 2 source interface gigabitethernet1/0/1</pre>	Specifies the SPAN session and the source port (monitored port). <ul style="list-style-type: none"> <li>• For <i>session_number</i>, the range is 1 to 66.</li> <li>• For <i>interface-id</i>, specifies the source port to monitor. Valid interfaces include physical interfaces and port-channel logical interfaces (<b>port-channel</b> <i>port-channel-number</i>). Valid port-channel numbers are 1 to 48.</li> <li>• For <i>vlan-id</i>, specify the source VLAN to monitor. The range is 1 to 4094 (excluding the RSPAN VLAN).</li> </ul> <p><b>Note</b> A single session can include multiple sources (ports or VLANs) defined in a series of commands, but you cannot combine source ports and source VLANs in one session.</p> <ul style="list-style-type: none"> <li>• (Optional) [,   -]—Specifies a series or range of interfaces. Enter a space before and after the comma; enter a space before and after the hyphen.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• (Optional) [<b>both</b>   <b>rx</b>   <b>tx</b>]—Specifies the direction of traffic to monitor. If you do not specify a traffic direction, the SPAN monitors both sent and received traffic.</li> <li>• <b>both</b>—Monitors both sent and received traffic. This is the default.</li> <li>• <b>rx</b>—Monitors received traffic.</li> <li>• <b>tx</b>—Monitors sent traffic.</li> </ul> <p><b>Note</b> You can use the <b>monitor session session_number source</b> command multiple times to configure multiple source ports.</p>
<b>Step 5</b>	<b>monitor session session_number destination remote vlan vlan-id</b>  <b>Example:</b>  <pre>Device(config)# monitor session 2 destination remote vlan 5</pre>	Specifies the RSPAN session and the destination RSPAN VLAN. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, enter the number defined in Step 4.</li> <li>• For <i>vlan-id</i>, specify the destination RSPAN VLAN to monitor.</li> </ul>
<b>Step 6</b>	<b>vlan vlan-id</b>  <b>Example:</b>  <pre>Device(config)# vlan 10</pre>	Enters the VLAN configuration mode. For <i>vlan-id</i> , specify the source RSPAN VLAN to monitor.
<b>Step 7</b>	<b>remote-span</b>  <b>Example:</b>  <pre>Device(config-vlan)# remote-span</pre>	Specifies that the VLAN you specified in Step 5 is part of the RSPAN VLAN.
<b>Step 8</b>	<b>exit</b>  <b>Example:</b>  <pre>Device(config-vlan)# exit</pre>	Returns to global configuration mode.
<b>Step 9</b>	<b>monitor session session_number filter {ip   ipv6   mac} access-group {access-list-number   name}</b>  <b>Example:</b>  <pre>Device(config)# monitor session 2 filter ip access-group 7</pre>	Specifies the RSPAN session, the types of packets to filter, and the ACLs to use in an FRSPAN session. <ul style="list-style-type: none"> <li>• For <i>session_number</i>, specify the session number entered in Step 4.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>For <i>access-list-number</i>, specify the ACL number that you want to use to filter traffic.</li> <li>For <i>name</i>, specify the ACL name that you want to use to filter traffic.</li> </ul>
<b>Step 10</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 11</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 12</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Flow-Based SPAN](#), on page 1114

[FSPAN and FRSPAN Configuration Guidelines](#), on page 1116

## Monitoring SPAN and RSPAN Operations

The following table describes the command used to display SPAN and RSPAN operations configuration and results to monitor operations:

*Table 78: Monitoring SPAN and RSPAN Operations*

Command	Purpose
<b>show monitor</b>	Displays the current SPAN, RSPAN, FSPAN, or FRSPAN configuration.



# SPAN and RSPAN Configuration Examples

## Example: Configuring Local SPAN

This example shows how to set up SPAN session 1 for monitoring source port traffic to a destination port. First, any existing SPAN configuration for session 1 is deleted, and then bidirectional traffic is mirrored from source Gigabit Ethernet port 1 to destination Gigabit Ethernet port 2, retaining the encapsulation method.

```
Device> enable
Device# configure terminal
Device(config)# no monitor session 1
Device(config)# monitor session 1 source interface gigabitethernet1/0/1
Device(config)# monitor session 1 destination interface gigabitethernet1/0/2
encapsulation replicate
Device(config)# end
```

This example shows how to remove port 1 as a SPAN source for SPAN session 1:

```
Device> enable
Device# configure terminal
Device(config)# no monitor session 1 source interface gigabitethernet1/0/1
Device(config)# end
```

This example shows how to disable received traffic monitoring on port 1, which was configured for bidirectional monitoring:

```
Device> enable
Device# configure terminal
Device(config)# no monitor session 1 source interface gigabitethernet1/0/1 rx
```

The monitoring of traffic received on port 1 is disabled, but traffic sent from this port continues to be monitored.

This example shows how to remove any existing configuration on SPAN session 2, configure SPAN session 2 to monitor received traffic on all ports belonging to VLANs 1 through 3, and send it to destination Gigabit Ethernet port 2. The configuration is then modified to also monitor all traffic on all ports belonging to VLAN 10.

```
Device> enable
Device# configure terminal
Device(config)# no monitor session 2
Device(config)# monitor session 2 source vlan 1 - 3 rx
Device(config)# monitor session 2 destination interface gigabitethernet1/0/2
Device(config)# monitor session 2 source vlan 10
Device(config)# end
```

This example shows how to remove any existing configuration on SPAN session 2, configure SPAN session 2 to monitor received traffic on Gigabit Ethernet source port 1, and send it to destination Gigabit Ethernet port 2 with the same egress encapsulation type as the source port, and to enable ingress forwarding with VLAN 6 as the default ingress VLAN:

```
Device> enable
Device# configure terminal
Device(config)# no monitor session 2
Device(config)# monitor session 2 source gigabitethernet0/1 rx
```

```
Device(config)# monitor session 2 destination interface gigabitethernet0/2 encapsulation
replicate ingress vlan 6
Device(config)# end
```

This example shows how to remove any existing configuration on SPAN session 2, configure SPAN session 2 to monitor traffic received on Gigabit Ethernet trunk port 2, and send traffic for only VLANs 1 through 5 and VLAN 9 to destination Gigabit Ethernet port 1:

```
Device> enable
Device# configure terminal
Device(config)# no monitor session 2
Device(config)# monitor session 2 source interface gigabitethernet1/0/2 rx
Device(config)# monitor session 2 filter vlan 1 - 5 , 9
Device(config)# monitor session 2 destination interface gigabitethernet1/0/1
Device(config)# end
```

### Related Topics

[Creating a Local SPAN Session and Configuring Incoming Traffic](#), on page 1119

[Local SPAN](#), on page 1106

[SPAN Sessions](#), on page 1108

[SPAN Configuration Guidelines](#), on page 1115

## Examples: Creating an RSPAN VLAN

This example shows how to create the RSPAN VLAN 901:

```
Device> enable
Device# configure terminal
Device(config)# vlan 901
Device(config-vlan)# remote span
Device(config-vlan)# end
```

This example shows how to remove any existing RSPAN configuration for session 1, configure RSPAN session 1 to monitor multiple source interfaces, and configure the destination as RSPAN VLAN 901:

```
Device> enable
Device# configure terminal
Device(config)# no monitor session 1
Device(config)# monitor session 1 source interface gigabitethernet1/0/1 tx
Device(config)# monitor session 1 source interface gigabitethernet1/0/2 rx
Device(config)# monitor session 1 source interface port-channel 2
Device(config)# monitor session 1 destination remote vlan 901
Device(config)# end
```

This example shows how to remove any existing configuration on RSPAN session 2, configure RSPAN session 2 to monitor traffic received on trunk port 2, and send traffic for only VLANs 1 through 5 and 9 to destination RSPAN VLAN 902:

```
Device> enable
Device# configure terminal
Device(config)# no monitor session 2
Device(config)# monitor session 2 source interface gigabitethernet1/0/2 rx
Device(config)# monitor session 2 filter vlan 1 - 5 , 9
Device(config)# monitor session 2 destination remote vlan 902
Device(config)# end
```

This example shows how to configure VLAN 901 as the source remote VLAN and port 1 as the destination interface:

```
Device> enable
Device# configure terminal
Device(config)# monitor session 1 source remote vlan 901
Device(config)# monitor session 1 destination interface gigabitethernet2/0/1
Device(config)# end
```

This example shows how to configure VLAN 901 as the source remote VLAN in RSPAN session 2, to configure Gigabit Ethernet source port 2 as the destination interface, and to enable forwarding of incoming traffic on the interface with VLAN 6 as the default receiving VLAN:

```
Device> enable
Device# configure terminal
Device(config)# monitor session 2 source remote vlan 901
Device(config)# monitor session 2 destination interface gigabitethernet1/0/2 ingress vlan 6
Device(config)# end
```

### Related Topics

- [Creating an RSPAN Destination Session and Configuring Incoming Traffic](#), on page 1130
- [Remote SPAN](#), on page 1107
- [RSPAN VLAN](#), on page 1112
- [RSPAN Configuration Guidelines](#), on page 1115

## Additional References

### Related Documents

Related Topic	Document Title
System Commands	<i>Network Management Command Reference, Cisco IOS XE Release 3E</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### Standards and RFCs

Standard/RFC	Title
None	-

**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for SPAN and RSPAN

Release	Modification
Cisco IOS XE 3.2SE	Switch Port Analyzer (SPAN): Allows monitoring of device traffic on a port or VLAN using a sniffer/analyzer or RMON probe.  This feature was introduced.
Cisco IOS XE 3.2SE	Flow-based Switch Port Analyzer (SPAN): Provides a method to capture only required data between end hosts by using specified filters. The filters are defined in terms of access lists that limit IPv4, IPv6 or IPv4 + IPv6, or non-IP traffic (MAC) between specified source and destination addresses.  This feature was introduced.

Release	Modification
Cisco IOS XE 3.2SE	<p>SPAN destination port support on EtherChannels: Provides the ability to configure a SPAN destination port on an EtherChannel.</p> <p>This feature was introduced.</p>
Cisco IOS XE 3.2SE	<p>Switch Port Analyzer (SPAN) - distributed egress SPAN: Provides distributed egress SPAN functionality onto line cards in conjunction with ingress SPAN already been distributed to line cards. By distributing egress SPAN functionalities onto line cards, the performance of the system is improved.</p> <p>This feature was introduced.</p>





## CHAPTER 75

# Configuring ERSPAN

This module describes how to configure Encapsulated Remote Switched Port Analyzer (ERSPAN). The Cisco ERSPAN feature allows you to monitor traffic on ports or VLANs and send the monitored traffic to destination ports.

- [Prerequisites for Configuring ERSPAN, on page 1145](#)
- [Restrictions for Configuring ERSPAN, on page 1145](#)
- [Information for Configuring ERSPAN, on page 1146](#)
- [How to Configure ERSPAN, on page 1147](#)
- [Configuration Examples for ERSPAN, on page 1149](#)
- [Verifying ERSPAN, on page 1150](#)
- [Additional References, on page 1151](#)
- [Feature Information for Configuring ERSPAN, on page 1152](#)

## Prerequisites for Configuring ERSPAN

- The ERSPAN feature requires IP routing to be enabled in the Global Configuration Mode.
- Only IPv4 delivery/transport header is supported.
- Access control list (ACL) filter is applied before sending the monitored traffic on to the tunnel.
- Only supports Type-II ERSPAN header.

## Restrictions for Configuring ERSPAN

The following restrictions apply for this feature:

- Destination sessions are not supported.
- A device supports up to 66 sessions. A maximum of 8 source sessions can be configured and the remaining sessions can be configured as RSPAN destination sessions. A source session can be a local SPAN source session or an RSPAN source session or an ERSPAN source session.
- You can configure either a list of ports or a list of VLANs as a source, but cannot configure both for a given session.

- When a session is configured through the ERSPAN CLI, the session ID and the session type cannot be changed. To change them, you must use the no form of the configuration commands to remove the session and then reconfigure the session.
- ERSPAN source sessions do not copy locally-sourced Remote SPAN (RSPAN) VLAN traffic from source trunk ports that carry RSPAN VLANs.
- ERSPAN source sessions do not copy locally-sourced ERSPAN GRE-encapsulated traffic from source ports.

## Information for Configuring ERSPAN

### ERSPAN Overview

The Cisco ERSPAN feature allows you to monitor traffic on ports or VLANs, and send the monitored traffic to destination ports. ERSPAN sends traffic to a network analyzer, such as a Switch Probe device or a Remote Monitoring (RMON) probe. ERSPAN supports source ports, source VLANs, and destination ports on different devices, which helps remote monitoring of multiple devices across a network.

ERSPAN supports encapsulated packets of up to 9180 bytes. ERSPAN consists of an ERSPAN source session, routable ERSPAN GRE-encapsulated traffic, and an ERSPAN destination session.

ERSPAN consists of an ERSPAN source session, routable ERSPAN GRE-encapsulated traffic, and an ERSPAN destination session. You can configure an ERSPAN source session, an ERSPAN destination session, or both on a device. A device on which only an ERSPAN source session is configured is called an ERSPAN source device, and a device on which only an ERSPAN destination session is configured is called an ERSPAN termination device. A device can act as both; an ERSPAN source device and a termination device.

For a source port or a source VLAN, the ERSPAN can monitor the ingress, egress, or both ingress and egress traffic. By default, ERSPAN monitors all traffic, including multicast, and Bridge Protocol Data Unit (BPDU) frames.

An ERSPAN source session is defined by the following parameters:

- A session ID
- List of source ports or source VLANs to be monitored by the session
- The destination and origin IP addresses, which are used as the destination and source IP addresses of the generic routing encapsulation (GRE) envelope for the captured traffic, respectively
- ERSPAN flow ID
- Optional attributes, such as, IP Time to Live (TTL), related to the GRE envelope



---

**Note**

ERSPAN source sessions do not copy ERSPAN GRE-encapsulated traffic from source ports. Each ERSPAN source session can have either ports or VLANs as sources, but not both.

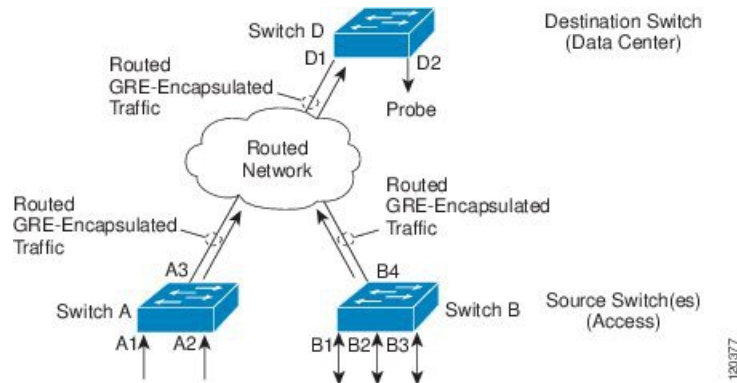
---





**Note** Because encapsulation is performed in the hardware, the CPU performance is not impacted.

**Figure 87: ERSPAN Configuration**



## ERSPAN Sources

The Cisco ERSPAN feature supports the following sources:

- Source ports—A source port that is monitored for traffic analysis. Source ports in any VLAN can be configured and trunk ports can be configured as source ports along with nontrunk source ports.
- Source VLANs—A VLAN that is monitored for traffic analysis.

The following interfaces are supported as source ports:

- GigabitEthernet
- PortChannel
- TenGigabitEthernet

## How to Configure ERSPAN

### Configuring an ERSPAN Source Session

The ERSPAN source session defines the session configuration parameters and the ports or VLANs to be monitored.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
	Switch> enable	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Switch# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>monitor session <i>span-session-number</i> type erspan-source</b> <b>Example:</b> Switch(config)# monitor session span-session-number type erspan-source	Defines an ERSPAN source session using the session ID and the session type, and enters ERSPAN monitor source session configuration mode. <ul style="list-style-type: none"> <li>• Session IDs for source sessions or destination sessions are in the same global ID space, so each session ID is globally unique for both session types.</li> <li>• The <i>span-session-number</i> and the session type (configured by the <b>erspan-source</b> keyword) cannot be changed once configured. Use the no form of this command to remove the session and then re-create the session with a new session ID or a new session type.</li> </ul>
<b>Step 4</b>	<b>description <i>description</i></b> <b>Example:</b> Switch(config-mon-erspan-src)# description source1	Describes the ERSPAN source session.
<b>Step 5</b>	<b>source {interface <i>type number</i>   vlan <i>vlan-ID</i>} [,   -] <b>both</b>   <b>rx</b>   <b>tx</b>}</b> <b>Example:</b> Switch(config-mon-erspan-src)# source interface fastethernet 0/1 rx	Configures the source interface or the VLAN, and the traffic direction to be monitored.
<b>Step 6</b>	<b>filter {ip access-group {<i>standard-access-list</i>   <i>expanded-access-list</i>   <i>acl-name</i>}   ipv6 access-group <i>acl-name</i>   mac access-group <i>acl-name</i>   vlan <i>vlan-ID</i> [, -]}</b> <b>Example:</b> Switch(config-mon-erspan-src)# filter vlan 3	(Optional) Configures source VLAN filtering when the ERSPAN source is a trunk port. <ul style="list-style-type: none"> <li>• <b>Note</b> You cannot include source VLANs and filter VLANs in the same session.</li> </ul>
<b>Step 7</b>	<b>no shutdown</b> <b>Example:</b> Switch(config-mon-erspan-src)# no shutdown	Disables the shutting down of the configured session.

	Command or Action	Purpose
<b>Step 8</b>	<b>destination</b> <b>Example:</b> Switch(config-mon-erspan-src)# destination	Defines an ERSPAN destination session and enters ERSPAN monitor destination session configuration mode.
<b>Step 9</b>	<b>ip address <i>ip-address</i></b> <b>Example:</b> Switch(config-mon-erspan-src-dst)# ip address 192.0.2.9	Configures an IP address for the ERSPAN destination session.
<b>Step 10</b>	<b>erspan-id <i>erspan-ID</i></b> <b>Example:</b> Switch(config-mon-erspan-src-dst)# erspan-id 2	Configures the ID used by the destination session to identify the ERSPAN traffic.
<b>Step 11</b>	<b>origin <i>ip-address</i></b> <b>Example:</b> Switch(config-mon-erspan-src-dst)# origin ip-address 203.0.113.2	Configures the IP address used as the destination for the ERSPAN traffic.
<b>Step 12</b>	<b>ip ttl <i>tll-value</i></b> <b>Example:</b> Switch(config-mon-erspan-src-dst)# erspan ttl 32	Configures Time to Live (TTL) values for packets in the ERSPAN traffic.
<b>Step 13</b>	<b>end</b> <b>Example:</b> Switch(config-mon-erspan-src-dst)# end	Exits ERSPAN monitor destination session configuration mode and returns to privileged EXEC mode.

## Configuration Examples for ERSPAN

### Example: Configuring an ERSPAN Source Session

```
Switch> enable
Switch# configure terminal
Switch(config)# monitor session 1 type erspan-source
Switch(config-mon-erspan-src)# description source1
Switch(config-mon-erspan-src)# source interface fastethernet 0/1 rx
Switch(config-mon-erspan-src)# filter vlan 3
Switch(config-mon-erspan-src)# no shutdown
Switch(config-mon-erspan-src)# destination
Switch(config-mon-erspan-src-dst)# ip address 192.0.2.9
Switch(config-mon-erspan-src-dst)# erspan-id 2
Switch(config-mon-erspan-src-dst)# origin ip-address 203.0.113.2
Switch(config-mon-erspan-src-dst)# ip ttl 32
```

```
Switch(config-mon-erspan-src-dst)# end
```

## Verifying ERSPAN

To verify the ERSPAN configuration, use the following commands:

The following is sample output from the **show monitor session erspan-source** command:

```
Switch# show monitor session erspan-source session
```

```
Type : ERSPAN Source Session
Status : Admin Enabled
Source Ports :
RX Only : Gi1/4/33
Destination IP Address : 192.0.2.1
Destination ERSPAN ID : 110
Origin IP Address : 10.10.10.216
IPv6 Flow Label : None
```

The following is sample output from the **show monitor session erspan-source detail** command:

```
Switch# show monitor session erspan-source detail
```

```
Type : ERSPAN Source Session
Status : Admin Enabled
Description : -
Source Ports :
RX Only : Gi1/4/33
TX Only : None
Both : None
Source VLANs :
RX Only : None
TX Only : None
Both : None
Source RSPAN VLAN : None
Destination Ports : None
Filter VLANs : None
Filter Addr Type :
RX Only : None
TX Only : None
Both : None
Filter Pkt Type :
RX Only : None
Dest RSPAN VLAN : None
IP Access-group : None
IPv6 Access-group : None
Destination IP Address : 192.0.2.1
Destination IPv6 Address : None
Destination IP VRF : None
Destination ERSPAN ID : 110
Origin IP Address : 10.10.10.216
IP QOS PREC : 0
IP TTL : 255
```

The following output from the **show capability feature monitor erspan-source** command displays information about the configured ERSPAN source sessions:

```
Switch# show capability feature monitor erspan-source
```

```
ERSPAN Source Session Supported: true
No of Rx ERSPAN source session: 8
No of Tx ERSPAN source session: 8
ERSPAN Header Type supported: II
ACL filter Supported: true
Fragmentation Supported: true
Truncation Supported: false
Sequence number Supported: false
QOS Supported: true
```

The following output from the **show capability feature monitor erspan-destination** command displays all the configured global built-in templates:

```
Switch# show capability feature monitor erspan-destination
```

```
ERSPAN Destination Session Supported: false
```

## Additional References

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>

### RFCs

Standard/RFC	Title
RFC 2784	Generic Routing Encapsulation (GRE)

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for Configuring ERSPAN

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

**Table 79: Feature Information for Configuring ERSPAN**

Feature Name	Releases	Feature Information
ERSPAN	Cisco IOS XE Denali 16.3.1	<p>This module describes how to configure Encapsulated Remote Switched Port Analyzer (ERSPAN). The Cisco ERSPAN feature allows you to monitor traffic on ports or VLANs and send the monitored traffic to destination ports over a generic routing encapsulation (GRE) tunnel in any VRF.</p> <p>In Cisco IOS XE Denali 16.3.1, this feature was introduced on Cisco Catalyst 3650 Series Switches and Cisco Catalyst 3850 Series Switches.</p> <p>The following commands were introduced or modified: <code>destination (ERSPAN)</code>, <code>erspan</code>, <code>filter (ERSPAN)</code>, and <code>show capability feature monitor</code>.</p> <p>The following commands were introduced or modified: <b><code>destination (ERSPAN)</code></b>, <b><code>filter (ERSPAN)</code></b>, and <b><code>show capability feature monitor</code></b>.</p>



# CHAPTER 76

## Configuring Packet Capture

- [Prerequisites for Packet Capture, on page 1153](#)
- [Restrictions for Packet Capture, on page 1154](#)
- [Introduction to Packet Capture, on page 1156](#)
- [Configuring Packet Capture, on page 1166](#)
- [Monitoring Packet Capture, on page 1183](#)
- [Additional References, on page 1200](#)

## Prerequisites for Packet Capture

### Prerequisites for Packet Capture

- Packet capture is supported on Catalyst 3850 and Catalyst 3650.
- Wireshark is supported only on switches running IP Base image or IP Services image.
- Embedded Packet Capture is supported only on switches running Lan Base image.

The Embedded Packet Capture (EPC) software subsystem consumes CPU and memory resources during its operation. You must have adequate system resources for different types of operations. Some guidelines for using the system resources are provided in the table below.

**Table 80: System Requirements for the EPC Subsystem**

System Resources	Requirements
Hardware	CPU utilization requirements are platform dependent.
Memory	The packet buffer is stored in DRAM. The size of the packet buffer is user specified.
Diskspace	Packets can be exported to external devices. No intermediate storage on flash disk is required.

# Restrictions for Packet Capture

## Restrictions for Packet Capture

- Starting in Cisco IOS Release XE 3.3.0(SE), global packet capture on Wireshark is not supported.
- Display filters are supported on Wireshark.
- The CLI for configuring Wireshark requires that the feature be executed only from EXEC mode. Actions that usually occur in configuration submode (such as defining capture points), are handled at the EXEC mode instead. All key commands are not NVGEN'd and are not synchronized to the standby supervisor in NSF and SSO scenarios.
- Packets captured in the output direction of an interface might not reflect the changes made by rewrite (includes TTL, VLAN tag, CoS, checksum, MAC addresses, DSCP, precedent, UP, etc.).
- The Rewrite information of both ingress and egress packets are not captured.
- Limiting circular file storage by file size is not supported.
- File limit is limited to the size of the flash in IP Base and IP Services.
- Decoding of protocols such as Control and Provisioning of Wireless Access Points (CAPWAP) Is supported in IP Base and IP Services.
- In IP Base and IP Services, in file mode, the packets will be written to the files without export.
- The LAN Base image supports Embedded Wireshark with the following limitations:
  - Capture filters and display filters are not supported.
  - Active capture decoding is not available.
  - The output format is different from previous releases.
- Embedded Packet Capture (EPC) captures multicast packets only on ingress and does not capture the replicated packets on egress.

### Wireless Packet Capture

- The only form of wireless capture is a CAPWAP tunnel capture.
- When capturing CAPWAP tunnels, no other interface types can be used as attachment points on the same capture point.
- Capturing multiple CAPWAP tunnels is supported.
- Core filters are not applied and should be omitted when capturing a CAPWAP tunnel.
- To capture a CAPWAP data tunnel, each CAPWAP tunnel is mapped to a physical port and an appropriate ACL will be applied to filter the traffic.
- To capture a CAPWAP non-data tunnel, the switch is set to capture traffic on all ports and apply an appropriate ACL to filter the traffic.



### Configuration Limitations

- Up to 8 capture points can be defined, but only one can be active at a time. You need to stop one before you can start the other.
- Neither VRFs, management ports, nor private VLANs can be used as attachment points.
- Only one ACL (IPv4, IPv6 or MAC) is allowed in a Wireshark class map.
- Wireshark cannot capture packets on a destination SPAN port.
- Wireshark stops capturing when one of the attachment points (interfaces) attached to a capture point stops working. For example, if the device that is associated with an attachment point is unplugged from the . To resume capturing, the capture must be restarted manually.
- CPU-injected packets are considered control plane packets. Therefore, these types of packets will not be captured on an interface egress capture.
- MAC ACL is only used for non-IP packets such as ARP. It will not be supported on a Layer 3 port or SVI.
- MAC filter will not capture IP packets even if it matches the MAC address. This applies to all interfaces (L2 Switchport, L3 Routed Port)
- MAC filter cannot capture L2 packets (ARP) on L3 interfaces.
- IPv6-based ACLs are not supported in VACL.
- Layer 2 EtherChannels are not supported.
- Starting from Cisco IOS release 16.1, Layer 3 PortChannel Support is available.
- It is not possible to modify a capture point parameter when a capture is already active or has started.
- ACL logging and Wireshark are incompatible. Once Wireshark is activated, it takes priority. All traffic, including that being captured by ACL logging on any ports, will be redirected to Wireshark. We recommend that you deactivate ACL logging before starting Wireshark. Otherwise, Wireshark traffic will be contaminated by ACL logging traffic.
- Wireshark does not capture packets dropped by floodblock.
- If you capture both PACL and RACL on the same port, only one copy is sent to the CPU. If you capture a DTLS-encrypted CAPWAP interface, two copies are sent to Wireshark, one encrypted and the other decrypted. The same behavior will occur if we capture a Layer 2 interface carrying DTLS-encrypted CAPWAP traffic. The core filter is based on the outer CAPWAP header.
- Starting from Cisco IOS release 16.1:
  - L3 port channel support is added.
  - Minor changes have been made in the display format.
  - Ability to display the number of packets in a cap file
  - Clearing the captured buffer deletes the buffer along with its contents. It cannot be run when the packet capture is active.
  - Additional warning message is displayed for control plane capturing.
  - In buffer mode, the packet display is allowed only after stop.

- Packet statistics displayed at stop, in IP Services and IP Base.
- Ability to query the number of packets captured in a pcap file.
- When the display is from a cap file, display details of the selected packet can be viewed using packet-number.
- Display filter can be used in file mode.
- Statistics of packet capture (packets and bytes received, dropped) can be displayed either during the capture or after capture stop.
- The system can query statistics on a pcap cap file's contents, as supported by Wireshark.
- The packet capture session is always in streaming mode irrespective of the size of the buffer. There is no lock-step mode anymore.
- Clearing buffer on an active capture point is supported only on Lan Base as this only clears the content. On all other licenses, it deletes the buffer itself, hence cannot be run during active capture.



---

**Warning** Control plane packets are not rate limited and performance impacting. Please use filters to limit control plane packet capture.

---

- If the user changes interface from Switch port to routed port (L2 -> L3) or vice versa, they must delete the capture point and create a new one, once the interface comes back up. Stop/start the capture point will not work.
- If the user deletes the file used by an active capture session, the capture session cannot create a new file, and all further packets captured are lost. The user will then need to restart the capture point.

# Introduction to Packet Capture

## Overview of Packet Capture Tool

The Packet Capture feature is an onboard packet capture facility that allows network administrators to capture packets flowing to, through, and from the device and to analyze them locally or save and export them for offline analysis by using tools such as Wireshark and Embedded Packet Capture (EPC). This feature simplifies network operations by allowing devices to become active participants in the management and operation of the network. This feature facilitates troubleshooting by gathering information about the packet format. This feature also facilitates application analysis and security.

The Embedded Packet Capture is supported on Lan Base. Embedded Packet Capture with Wireshark is supported on IP Base and IP Services.

# Information about Wireshark

## Wireshark Overview

Wireshark is a packet analyzer program, formerly known as Ethereal, that supports multiple protocols and presents information in a text-based user interface.

The ability to capture and analyze traffic provides data on network activity. Prior to Cisco IOS Release XE 3.3.0(SE), only two features addressed this need: SPAN and debug platform packet. Both have limitations. SPAN is ideal for capturing packets, but can only deliver them by forwarding them to some specified local or remote destination; it provides no local display or analysis support.

So the need exists for a traffic capture and analysis mechanism that is applicable to both hardware and software forwarded traffic and that provides strong packet capture, display, and analysis support, preferably using a well known interface.

Wireshark dumps packets to a file using a well known format called .pcap, and is applied or enabled on individual interfaces. You specify an interface in EXEC mode along with the filter and other parameters. The Wireshark application is applied only when you enter a **start** command, and is removed only when Wireshark stops capturing packets either automatically or manually.

**Note**

The current version of Wireshark installed on the switch is 1.10.8.

## Capture Points

A capture point is the central policy definition of the Wireshark feature. The capture point describes all of the characteristics associated with a given instance of Wireshark: which packets to capture, where to capture them from, what to do with the captured packets, and when to stop. Capture points can be modified after creation, and do not become active until explicitly activated with a **start** command. This process is termed activating the capture point or starting the capture point. Capture points are identified by name and can also be manually or automatically deactivated or stopped.

Multiple capture points can be defined, but only one can be active at a time. You need to stop one before you can start the other.

In case of stacked systems, the capture point is activated on the active member. A switchover will terminate any active packet capture session and it will have to be restarted.

## Attachment Points

An attachment point is a point in the logical packet process path associated with a capture point. An attachment point is an attribute of the capture point. Packets that impact an attachment point are tested against capture point filters; packets that match are copied and sent to the associated Wireshark instance of the capture point. A specific capture point can be associated with multiple attachment points, with limits on mixing attachment points of different types. Some restrictions apply when you specify attachment points of different types. Attachment points are directional (input or output or both) with the exception of the Layer 2 VLAN attachment point, which is always bidirectional.

In case of stacked systems, the attachment points on all stack members are valid. EPC captures the packets from all the defined attachment points. However these packets are processed only on the active member.

## Filters

Filters are attributes of a capture point that identify and limit the subset of traffic traveling through the attachment point of a capture point, which is copied and passed to Wireshark. To be displayed by Wireshark, a packet must pass through an attachment point, as well as all of the filters associated with the capture point.

A capture point has the following types of filters:

- Core system filter—The core system filter is applied by hardware, and its match criteria is limited by hardware. This filter determines whether hardware-forwarded traffic is copied to software for Wireshark purposes.
- Display filter—The display filter is applied by Wireshark. Packets that fail the display filter are not displayed.

### Core System Filter

You can specify core system filter match criteria by using the class map or ACL, or explicitly by using the CLI.

**Note**

When specifying CAPWAP as an attachment point, the core system filter is not used.

In some installations, you need to obtain authorization to modify the configuration, which can lead to extended delays if the approval process is lengthy. This can limit the ability of network administrators to monitor and analyze traffic. To address this situation, Wireshark supports explicit specification of core system filter match criteria from the EXEC mode CLI. The disadvantage is that the match criteria that you can specify is a limited subset of what class map supports, such as MAC, IP source and destination addresses, ether-type, IP protocol, and TCP/UDP source and destination ports.

If you prefer to use configuration mode, you can define ACLs or have class maps refer capture points to them. Explicit and ACL-based match criteria are used internally to construct class maps and policy maps.

Note The ACL and class map configuration are part of the system and not aspects of the Wireshark feature.

### Display Filter

With the display filter, you can direct Wireshark to further narrow the set of packets to display when decoding and displaying from a .pcap file.

## Actions

Wireshark can be invoked on live traffic or on a previously existing .pcap file. When invoked on live traffic, it can perform four types of actions on packets that pass its display filters:

- Captures to buffer in memory to decode and analyze and store
- Stores to a .pcap file
- Decodes and displays
- Stores and displays

When invoked on a .pcap file only, only the decode and display action is applicable.

## Storage of Captured Packets to Buffer in Memory

Packets can be stored in the capture buffer in memory for subsequent decode, analysis, or storage to a .pcap file.

The capture buffer can be in linear or circular mode. In linear mode, new packets are discarded when the buffer is full. In circular mode, if the buffer is full, the oldest packets are discarded to accommodate the new packets. Although the buffer can also be cleared when needed, this mode is mainly used for debugging network traffic. However, it is not possible to only clear the contents of the buffer alone without deleting it. Stop the current captures and restart the capture again for this to take effect.



---

**Note** If you have more than one capture that is storing packets in a buffer, clear the buffer before starting a new capture to avoid memory loss.

---

## Storage of Captured Packets to a .pcap File



---

**Note** When Wireshark is used on switches in a stack, packet captures can be stored only on flash or USB flash devices connected to the active switch.

For example, if flash1 is connected to the active switch, and flash2 is connected to the secondary switch, only flash1 can be used to store packet captures.

Attempts to store packet captures on devices other than flash or USB flash devices connected to the active switch will probably result in errors.

---

Wireshark can store captured packets to a .pcap file. The capture file can be located on the following storage devices:

- on-board flash storage (flash:)
- USB drive (usbflash0:)



---

**Note** Attempts to store packet captures on unsupported devices or devices not connected to the active switch will probably result in errors.

---

When configuring a Wireshark capture point, you can associate a filename. When the capture point is activated, Wireshark creates a file with the specified name and writes packets to it. If the file already exists at the time of creation of the capture point, Wireshark queries you as to whether the file can be overwritten. If the file already exists at the time of activating the capture point, Wireshark will overwrite the existing file. Only one capture point may be associated with a given filename.

If the destination of the Wireshark writing process is full, Wireshark fails with partial data in the file. You must ensure that there is sufficient space in the file system before you start the capture session. With Cisco IOS Release IOS XE 3.3.0(SE), the file system full status is not detected for some storage devices.

You can reduce the required storage space by retaining only a segment, instead of the entire packet. Typically, you do not require details beyond the first 64 or 128 bytes. The default behavior is to store the entire packet.

To avoid possible packet drops when processing and writing to the file system, Wireshark can optionally use a memory buffer to temporarily hold packets as they arrive. Memory buffer size can be specified when the capture point is associated with a .pcap file.

## Packet Decoding and Display

Wireshark can decode and display packets to the console. This functionality is possible for capture points applied to live traffic and for capture points applied to a previously existing .pcap file.



---

**Note** Decoding and displaying packets may be CPU intensive.

---

Wireshark can decode and display packet details for a wide variety of packet formats. The details are displayed by entering the **monitor capture name start** command with one of the following keyword options, which place you into a display and decode mode:

- **brief**—Displays one line per packet (the default).
- **detailed**—Decodes and displays all the fields of all the packets whose protocols are supported. Detailed modes require more CPU than the other two modes.
- **(hexadecimal) dump**—Displays one line per packet as a hexadecimal dump of the packet data and the printable characters of each packet.

When you enter the **capture** command with the decode and display option, the Wireshark output is returned to Cisco IOS and displayed on the console unchanged.

### Live Traffic Display

Wireshark receives copies of packets from the core system. Wireshark applies its display filters to discard uninteresting packets, and then decodes and displays the remaining packets.

### .pcap File Display

Wireshark can decode and display packets from a previously stored .pcap file and direct the display filter to selectively displayed packets.

## Packet Storage and Display

Functionally, this mode is a combination of the previous two modes. Wireshark stores packets in the specified .pcap file and decodes and displays them to the console. Only the core filters are applicable here.

## Wireshark Capture Point Activation and Deactivation

After a Wireshark capture point has been defined with its attachment points, filters, actions, and other options, it must be activated. Until the capture point is activated, it does not actually capture packets.

Before a capture point is activated, some functional checks are performed. A capture point cannot be activated if it has neither a core system filter nor attachment points defined. Attempting to activate a capture point that does not meet these requirements generates an error.\*



---

**Note** \*When performing a wireless capture with a CAPWAP tunneling interface, the core system filter is not required and cannot be used.

---

The display filters are specified as needed.

After Wireshark capture points are activated, they can be deactivated in multiple ways. A capture point that is storing only packets to a .pcap file can be halted manually or configured with time or packet limits, after which the capture point halts automatically.

When a Wireshark capture point is activated, a fixed rate policer is applied automatically in the hardware so that the CPU is not flooded with Wireshark-directed packets. The disadvantage of the rate policer is that you cannot capture contiguous packets beyond the established rate even if more resources are available.

The set packet capture rate is 1000 packets per sec (pps). The 1000 pps limit is applied to the sum of all attachment points. For example, if we have a capture session with 3 attachment points, the rates of all 3 attachment points added together is policed to 1000 pps.



---

**Note** Policer is not supported for control-plane packet capture. When activating control-plane capture points, you need to be extra cautious, so that it does not flood the CPU.

---

## Wireshark Features

This section describes how Wireshark features function in the environment:

- If port security and Wireshark are applied on an ingress capture, a packet that is dropped by port security will still be captured by Wireshark. If port security is applied on an ingress capture, and Wireshark is applied on an egress capture, a packet that is dropped by port security will not be captured by Wireshark.
- Packets dropped by Dynamic ARP Inspection (DAI) are not captured by Wireshark.
- If a port that is in STP blocked state is used as an attachment point and the core filter is matched, Wireshark will capture the packets that come into the port, even though the packets will be dropped by the switch.
- Classification-based security features—Packets that are dropped by input classification-based security features (such as ACLs and IPSG) are not caught by Wireshark capture points that are connected to attachment points at the same layer. In contrast, packets that are dropped by output classification-based security features are caught by Wireshark capture points that are connected to attachment points at the same layer. The logical model is that the Wireshark attachment point occurs after the security feature lookup on the input side, and symmetrically before the security feature lookup on the output side.

On ingress, a packet goes through a Layer 2 port, a VLAN, and a Layer 3 port/SVI. On egress, the packet goes through a Layer 3 port/SVI, a VLAN, and a Layer 2 port. If the attachment point is before the point where the packet is dropped, Wireshark will capture the packet. Otherwise, Wireshark will not capture the packet. For example, Wireshark capture policies connected to Layer 2 attachment points in the input direction capture packets dropped by Layer 3 classification-based security features. Symmetrically, Wireshark capture policies attached to Layer 3 attachment points in the output direction capture packets dropped by Layer 2 classification-based security features.

- Routed ports and switch virtual interfaces (SVIs)—Wireshark cannot capture the output of an SVI because the packets that go out of an SVI's output are generated by CPU. To capture these packets, include the control plane as an attachment point.

- VLANs—Starting with Cisco IOS Release 16.1, when a VLAN is used as a Wireshark attachment point, packet capture is supported on L2 and L3 in both input and output directions.
- Redirection features—In the input direction, features traffic redirected by Layer 3 (such as PBR and WCCP) are logically later than Layer 3 Wireshark attachment points. Wireshark captures these packets even though they might later be redirected out another Layer 3 interface. Symmetrically, output features redirected by Layer 3 (such as egress WCCP) are logically prior to Layer 3 Wireshark attachment points, and Wireshark will not capture them.
- SPAN—Wireshark cannot capture packets on interface configured as a SPAN destination.
- SPAN—Wireshark is able to capture packets on interfaces configured as a SPAN source in the ingress direction, and may be available for egress direction too.
- You can capture packets from a maximum of 1000 VLANs at a time, if no ACLs are applied. If ACLs are applied, the hardware will have less space for Wireshark to use. As a result, the maximum number of VLANs than can be used for packet capture at a time will be lower. Using more than 1000 VLANs tunnels at a time or extensive ACLs might have unpredictable results. For example, mobility may go down.



---

**Note** Capturing an excessive number of attachment points at the same time is strongly discouraged because it may cause excessive CPU utilization and unpredictable hardware behavior.

---

### Wireless Packet Capture in Wireshark

- Wireless traffic is encapsulated inside CAPWAP packets. However, capturing only a particular wireless client's traffic inside a CAPWAP tunnel is not supported when using the CAPWAP tunnel as an attachment point. To capture only a particular wireless client's traffic, use the client VLAN as an attachment point and formulate the core filter accordingly.
- Limited decoding of inner wireless traffic is supported. Decoding of inner wireless packets inside encrypted CAPWAP tunnels is not supported.
- No other interface type can be used with the CAPWAP tunneling interface on the same capture point. A CAPWAP tunneling interface and a Level 2 port cannot be attachment points on the same capture point.
- You cannot specify a core filter when capturing packets for Wireshark via the CAPWAP tunnel. However, you can use the Wireshark display filters for filtering wireless client traffic against a specific wireless client.
- You can capture packets from a maximum of 135 CAPWAP tunnels at a time if no ACLs are applied. If ACLs are applied, the hardware memory will have less space for Wireshark to use. As a result, the maximum number of CAPWAP tunnels than can be used for packet capture at a time will be lower. Using more than 135 CAPWAP tunnels at a time or using extensive ACLs might have unpredictable results. For example, mobility may go down.



---

**Note** Capturing an excessive number of attachment points at the same time is strongly discouraged because it may cause excessive CPU utilization and unpredictable hardware behavior.

---



## Guidelines for Wireshark

- During Wireshark packet capture, hardware forwarding happens concurrently.
- Before starting a Wireshark capture process, ensure that CPU usage is moderate and that sufficient memory (at least 200 MB) is available.
- If you plan to store packets to a storage file, ensure that sufficient space is available before beginning a Wireshark capture process.
- The CPU usage during Wireshark capture depends on how many packets match the specified conditions and on the intended actions for the matched packets (store, decode and display, or both).
- Where possible, keep the capture to the minimum (limit by packets, duration) to avoid high CPU usage and other undesirable conditions.
- Because packet forwarding typically occurs in hardware, packets are not copied to the CPU for software processing. For Wireshark packet capture, packets are copied and delivered to the CPU, which causes an increase in CPU usage.

To avoid high CPU usage, do the following:

- Attach only relevant ports.
  - Use a class map, and secondarily, an access list to express match conditions. If neither is viable, use an explicit, in-line filter.
  - Adhere closely to the filter rules. Restrict the traffic type (such as, IPv4 only) with a restrictive, rather than relaxed ACL, which elicits unwanted traffic.
- Always limit packet capture to either a shorter duration or a smaller packet number. The parameters of the capture command enable you to specify the following:
    - Capture duration
    - Number of packets captured
    - File size
    - Packet segment size
  - Run a capture session without limits if you know that very little traffic matches the core filter.
  - You might experience high CPU (or memory) usage if:
    - You leave a capture session enabled and unattended for a long period of time, resulting in unanticipated bursts of traffic.
    - You launch a capture session with ring files or capture buffer and leave it unattended for a long time, resulting in performance or system health issues.
  - During a capture session, watch for high CPU usage and memory consumption due to Wireshark that may impact performance or health. If these situations arise, stop the Wireshark session immediately.
  - Avoid decoding and displaying packets from a .pcap file for a large file. Instead, transfer the .pcap file to a PC and run Wireshark on the PC.

- You can define up to eight Wireshark instances. An active **show** command that decodes and displays packets from a .pcap file or capture buffer counts as one instance. However, only one of the instances can be active.
- Whenever an ACL that is associated with a running capture is modified, you must restart the capture for the ACL modifications to take effect. If you do not restart the capture, it will continue to use the original ACL as if it had not been modified.
- To avoid packet loss, consider the following:
  - Use store-only (when you do not specify the display option) while capturing live packets rather than decode and display, which is a CPU-intensive operation (especially in detailed mode).
  - If you have more than one capture that is storing packets in a buffer, clear the buffer before starting a new capture to avoid memory loss.
  - If you use the default buffer size and see that you are losing packets, you can increase the buffer size to avoid losing packets.
  - Writing to flash disk is a CPU-intensive operation, so if the capture rate is insufficient, you may want to use a buffer capture.
  - The Wireshark capture session always operates in streaming mode at the rate of 1000 pps.
- The streaming capture mode rate is 1000 pps.
- If you want to decode and display live packets in the console window, ensure that the Wireshark session is bounded by a short capture duration.




---

**Warning**

A Wireshark session with either a longer duration limit or no capture duration (using a terminal with no auto-more support using the **term len 0** command) may make the console or terminal unusable.

---

- When using Wireshark to capture live traffic that leads to high CPU, usage, consider applying a QoS policy temporarily to limit the actual traffic until the capture process concludes.
- All Wireshark-related commands are in EXEC mode; no configuration commands exist for Wireshark. If you need to use access list or class-map in the Wireshark CLI, you must define an access list and class map with configuration commands.
- No specific order applies when defining a capture point; you can define capture point parameters in any order, provided that CLI allows this. The Wireshark CLI allows as many parameters as possible on a single line. This limits the number of commands required to define a capture point.
- All parameters except attachment points take a single value. Generally, you can replace the value with a new one by reentering the command. After user confirmation, the system accepts the new value and overrides the older one. A **no** form of the command is unnecessary to provide a new value, but it is necessary to remove a parameter.
- Wireshark allows you to specify one or more attachment points. To add more than one attachment point, reenter the command with the new attachment point. To remove an attachment point, use the **no** form of the command. You can specify an interface range as an attachment point. For example, enter **monitor capture mycap interface GigabitEthernet1/0/1 in** where interface GigabitEthernet1/0/1 is an attachment point.

If you also need to attach interface GigabitEthernet1/0/2, specify it in another line as follows:

**monitor capture mycap interface GigabitEthernet1/0/2 in**

- You cannot make changes to a capture point when the capture is active.
- The action you want to perform determines which parameters are mandatory. The Wireshark CLI allows you to specify or modify any parameter prior to entering the **start** command. When you enter the **start** command, Wireshark will start only after determining that all mandatory parameters have been provided.
- If the file already exists at the time of creation of the capture point, Wireshark queries you as to whether the file can be overwritten. If the file already exists at the time of activating the capture point, Wireshark will overwrite the existing file.
- The core filter can be an explicit filter, access list, or class map. Specifying a newer filter of these types replaces the existing one.




---

**Note** A core filter is required except when using a CAPWAP tunnel interface as a capture point attachment point.

---

- You can terminate a Wireshark session with an explicit **stop** command or by entering **q** in automore mode. The session could terminate itself automatically when a stop condition such as duration or packet capture limit is met, or if an internal error occurs, or resource is full (specifically if disk is full in file mode).
- Dropped packets will not be shown at the end of the capture. However, only the count of dropped, oversized packets will be displayed.

## Default Wireshark Configuration

The table below shows the default Wireshark configuration.

Feature	Default Setting
Duration	No limit
Packets	No limit
Packet-length	No limit (full packet)
File size	No limit
Ring file storage	No
Buffer storage mode	Linear

## Information About Embedded Packet Capture

### Embedded Packet Capture Overview

Embedded Packet Capture (EPC) provides an embedded systems management facility that helps in tracing and troubleshooting packets. This feature allows network administrators to capture data packets flowing through, to, and from a Cisco device. The network administrator may define the capture buffer size and type

(circular, or linear) and the maximum number of bytes of each packet to capture. The packet capture rate can be throttled using further administrative controls. For example, options allow for filtering the packets to be captured using an Access Control List and, optionally, further defined by specifying a maximum packet capture rate or by specifying a sampling interval.

## Benefits of Embedded Packet Capture

- Ability to capture IPv4 and IPv6 packets in the device, and also capture non-IP packets with MAC filter or match any MAC address.
- Extensible infrastructure for enabling packet capture points. A capture point is a traffic transit point where a packet is captured and associated with a buffer.
- Facility to export the packet capture in packet capture file (PCAP) format suitable for analysis using any external tool.
- Methods to decode data packets captured with varying degrees of detail.

## Packet Data Capture

Packet data capture is the capture of data packets that are then stored in a buffer. You can define packet data captures by providing unique names and parameters.

You can perform the following actions on the capture:

- Activate captures at any interface.
- Apply access control lists (ACLs) or class maps to capture points.



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**Note** Network Based Application Recognition (NBAR) and MAC-style class map is not supported.

---

- Destroy captures.
- Specify buffer storage parameters such as size and type. The size ranges from 1 MB to 100 MB. The default buffer is linear;; the other option for the buffer is circular.
- Specify match criteria that includes information about the protocol, IP address or port address.

# Configuring Packet Capture

## How to Configure Wireshark

To configure Wireshark, perform these basic steps.

1. Define a capture point.
2. (Optional) Add or modify the capture point's parameters.
3. Activate or deactivate a capture point.

4. Delete the capture point when you are no longer using it.

## Defining a Capture Point

The example in this procedure defines a very simple capture point. If you choose, you can define a capture point and all of its parameters with one instance of the **monitor capture** command.



**Note** You must define an attachment point, direction of capture, and core filter to have a functional capture point.

An exception to needing to define a core filter is when you are defining a wireless capture point using a CAPWAP tunneling interface. In this case, you do not define your core filter. It cannot be used.

Follow these steps to define a capture point.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>show capwap summary</b> <b>Example:</b> Device# <b>show capwap summary</b>	Displays the CAPWAP tunnels available as attachment points for a wireless capture. <p><b>Note</b> Use this command only if you are using a CAPWAP tunnel as an attachment point to perform a wireless capture. See the CAPWAP example in the examples section.</p>
<b>Step 3</b>	<b>monitor capture</b> { <i>capture-name</i> } { <b>interface</b> <i>interface-type</i> <i>interface-id</i>   <b>control-plane</b> } { <b>in</b>   <b>out</b>   <b>both</b> } <b>Example:</b> Device# <b>monitor capture mycap interface GigabitEthernet1/0/1 in</b>	Defines the capture point, specifies the attachment point with which the capture point is associated, and specifies the direction of the capture. <p>The keywords have these meanings:</p> <ul style="list-style-type: none"> <li>• <i>capture-name</i>—Specifies the name of the capture point to be defined (mycap is used in the example). Capture Name should be less than or equal to 8 characters. Only alphanumeric characters and underscore ( _ ) is permitted</li> <li>• (Optional) <b>interface</b> <i>interface-type</i> <i>interface-id</i>—Specifies the attachment point with which the capture point is associated (GigabitEthernet1/0/1 is used in the example).</li> </ul>

	Command or Action	Purpose
		<p><b>Note</b> Optionally, you can define multiple attachment points and all of the parameters for this capture point with this one command instance. These parameters are discussed in the instructions for modifying capture point parameters. Range support is also available both for adding and removing attachment points.</p> <p>Use one of the following for <i>interface-type</i>:</p> <ul style="list-style-type: none"> <li>• <b>GigabitEthernet</b>—Specifies the attachment point as GigabitEthernet.</li> <li>• <b>vlan</b>—Specifies the attachment point as a VLAN.</li> </ul> <p><b>Note</b> Only ingress capture (in) is allowed when using this interface as an attachment point.</p> <ul style="list-style-type: none"> <li>• <b>capwap</b>—Specifies the attachment point as a CAPWAP tunnel.</li> </ul> <p><b>Note</b> When using this interface as an attachment point, a core filter cannot be used.</p> <ul style="list-style-type: none"> <li>• (Optional) <b>control-plane</b>—Specifies the control plane as an attachment point.</li> <li>• <b>in   out   both</b>—Specifies the direction of capture.</li> </ul>
<b>Step 4</b>	<p><b>monitor capture</b> {<i>capture-name</i>} [<b>match</b> {<b>any</b>   <b>ipv4 any any</b>   <b>ipv6</b>} <b>any any</b>]</p> <p><b>Example:</b></p> <pre>Device# monitor capture mycap interface GigabitEthernet1/0/1 in match any</pre>	<p>Defines the core system filter.</p> <p><b>Note</b> When using the CAPWAP tunneling interface as an attachment point, do not perform this step because a core filter cannot be used.</p> <p>The keywords have these meanings:</p> <ul style="list-style-type: none"> <li>• <i>capture-name</i>—Specifies the name of the capture point to be defined (mycap is used in the example).</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>match</b>—Specifies a filter. The first filter defined is the core filter.</li> </ul> <p><b>Note</b> A capture point cannot be activated if it has neither a core system filter nor attachment points defined. Attempting to activate a capture point that does not meet these requirements generates an error.</p> <ul style="list-style-type: none"> <li>• <b>ipv4</b>—Specifies an IP version 4 filter.</li> <li>• <b>ipv6</b>—Specifies an IP version 6 filter.</li> </ul>
<b>Step 5</b>	<p><b>show monitor capture</b> {<i>capture-name</i>} [<b>parameter</b>]</p> <p><b>Example:</b></p> <pre>Device# show monitor capture mycap parameter   monitor capture mycap interface   GigabitEthernet1/0/1 in   monitor capture mycap match any</pre>	Displays the capture point parameters that you defined in Step 2 and confirms that you defined a capture point.
<b>Step 6</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 7</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

### Example

To define a capture point with a CAPWAP attachment point:

```
Device# show capwap summary
```

```
CAPWAP Tunnels General Statistics:
  Number of Capwap Data Tunnels      = 1
  Number of Capwap Mobility Tunnels   = 0
  Number of Capwap Multicast Tunnels = 0
```

```
Name      APName                                     Type PhyPortIf Mode      McastIf
-----
Ca0      AP442b.03a9.6715                          data Gi3/0/6  unicast  -
```

```

Name      SrcIP          SrcPort DestIP          DstPort DtlsEn MTU      Xact
-----
Ca0       10.10.14.32   5247   10.10.14.2     38514   No     1449    0

```

```

Device# monitor capture mycap interface capwap 0 both
Device# monitor capture mycap file location flash:mycap.pcap
Device# monitor capture mycap file buffer-size 1
Device# monitor capture mycap start

```

```
*Aug 20 11:02:21.983: %BUFCAP-6-ENABLE: Capture Point mycap enabled.on
```

```

Device# show monitor capture mycap parameter
      monitor capture mycap interface capwap 0 in
      monitor capture mycap interface capwap 0 out
      monitor capture mycap file location flash:mycap.pcap buffer-size 1
Device#
Device# show monitor capture mycap

```

```

Status Information for Capture mycap
Target Type:
Interface: CAPWAP,
  Ingress:
0
  Egress:
0
  Status : Active
Filter Details:
  Capture all packets
Buffer Details:
  Buffer Type: LINEAR (default)
File Details:
  Associated file name: flash:mycap.pcap
  Size of buffer(in MB): 1
Limit Details:
  Number of Packets to capture: 0 (no limit)
  Packet Capture duration: 0 (no limit)
  Packet Size to capture: 0 (no limit)
  Packets per second: 0 (no limit)
  Packet sampling rate: 0 (no sampling)

```

```

Device#
Device# show monitor capture file flash:mycap.pcap
 1  0.000000 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,
Flags=.....
 2  0.499974 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,
Flags=.....
 3  2.000000 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,
Flags=.....
 4  2.499974 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,
Flags=.....
 5  3.000000 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,
Flags=.....
 6  4.000000 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,
Flags=.....
 7  4.499974 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,
Flags=.....
 8  5.000000 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,
Flags=.....
 9  5.499974 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,
Flags=.....
10  6.000000 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,
Flags=.....
11  8.000000 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,

```



```

Flags=.....
12 9.225986 10.10.14.2 -> 10.10.14.32 DTLSv1.0 Application Data
13 9.225986 10.10.14.2 -> 10.10.14.32 DTLSv1.0 Application Data
14 9.225986 10.10.14.2 -> 10.10.14.32 DTLSv1.0 Application Data
15 9.231998 10.10.14.2 -> 10.10.14.32 DTLSv1.0 Application Data
16 9.231998 10.10.14.2 -> 10.10.14.32 DTLSv1.0 Application Data
17 9.231998 10.10.14.2 -> 10.10.14.32 DTLSv1.0 Application Data
18 9.236987 10.10.14.2 -> 10.10.14.32 DTLSv1.0 Application Data
19 10.000000 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,
Flags=.....
20 10.499974 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,
Flags=.....
21 12.000000 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,
Flags=.....
22 12.239993 10.10.14.2 -> 10.10.14.32 DTLSv1.0 Application Data
23 12.244997 10.10.14.2 -> 10.10.14.32 DTLSv1.0 Application Data
24 12.244997 10.10.14.2 -> 10.10.14.32 DTLSv1.0 Application Data
25 12.250994 10.10.14.2 -> 10.10.14.32 DTLSv1.0 Application Data
26 12.256990 10.10.14.2 -> 10.10.14.32 DTLSv1.0 Application Data
27 12.262987 10.10.14.2 -> 10.10.14.32 DTLSv1.0 Application Data
28 12.499974 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,
Flags=.....
29 12.802012 10.10.14.3 -> 10.10.14.255 NBNS Name query NB WPAD.<00>
30 13.000000 00:00:00:00:00:00 -> 3c:ce:73:39:c6:60 IEEE 802.11 Probe Request, SN=0, FN=0,
Flags=.....

```

### What to do next

You can add additional attachment points, modify the parameters of your capture point, then activate it, or if you want to use your capture point just as it is, you can now activate it.



**Note** You cannot change a capture point's parameters using the methods presented in this topic.

If the user enters an incorrect capture name, or an invalid/non existing attachment point, the switch will show errors like *"Capture Name should be less than or equal to 8 characters. Only alphanumeric characters and underscore ( \_ ) is permitted"* and *"% Invalid input detected at '^' marker"* respectively.

## Adding or Modifying Capture Point Parameters

Although listed in sequence, the steps to specify values for the parameters can be executed in any order. You can also specify them in one, two, or several lines. Except for attachment points, which can be multiple, you can replace any value with a more recent value by redefining the same option. You will need to confirm interactively when certain parameters already specified are being modified.

Follow these steps to modify a capture point's parameters.

### Before you begin

A capture point must be defined before you can use these instructions.

### Procedure

	Command or Action	Purpose
Step 1	enable	Enables privileged EXEC mode.

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<p><b>monitor capture</b> {<i>capture-name</i>} <b>match</b> {<b>any</b>   <b>mac</b> <i>mac-match-string</i>   <b>ipv4</b> {<b>any</b>   <b>host</b>   <b>protocol</b>} {<b>any</b>   <b>host</b>}   <b>ipv6</b> {<b>any</b>   <b>host</b>   <b>protocol</b>} {<b>any</b>   <b>host</b>}}</p> <p><b>Example:</b></p> <pre>Device# monitor capture mycap match ipv4 any any</pre>	<p>Defines the core system filter (<b>ipv4 any any</b>), defined either explicitly, through ACL or through a class map.</p> <p><b>Note</b> If you are defining a wireless capture point using a CAPWAP tunneling interface, this command will have no effect, so it should not be used.</p>
<b>Step 3</b>	<p><b>monitor capture</b> {<i>capture-name</i>} <b>limit</b> { [<b>duration</b> <i>seconds</i>] [<b>packet-length</b> <i>size</i>] [<b>packets</b> <i>num</i>] }</p> <p><b>Example:</b></p> <pre>Device# monitor capture mycap limit duration 60 packet-len 400</pre>	<p>Specifies the session limit in seconds (60), packets captured, or the packet segment length to be retained by Wireshark (400).</p>
<b>Step 4</b>	<p><b>monitor capture</b> {<i>capture-name</i>} <b>file</b> {<i>location filename</i>}</p> <p><b>Example:</b></p> <pre>Device# monitor capture mycap file location flash:mycap.pcap</pre>	<p>Specifies the file association, if the capture point intends to capture packets rather than only display them.</p> <p><b>Note</b> If the file already exists, you have to confirm if it can be overwritten.</p> <p><b>Note</b> File option does not exist on LAN base license.</p>
<b>Step 5</b>	<p><b>monitor capture</b> {<i>capture-name</i>} <b>file</b> {<i>buffer-size size</i>}</p> <p><b>Example:</b></p> <pre>Device# monitor capture mycap file buffer-size 100</pre>	<p>Specifies the size of the memory buffer used by Wireshark to handle traffic bursts.</p>
<b>Step 6</b>	<p><b>show monitor capture</b> {<i>capture-name</i>} [<b>parameter</b>]</p> <p><b>Example:</b></p> <pre>Device# show monitor capture mycap parameter monitor capture mycap interface GigabitEthernet1/0/1 in monitor capture mycap match ipv4 any any monitor capture mycap limit duration 60 packet-len 400 monitor capture point mycap file location bootdisk:mycap.pcap</pre>	<p>Displays the capture point parameters that you defined previously.</p>

	Command or Action	Purpose
	<code>monitor capture mycap file buffer-size 100</code>	
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Examples

### Modifying Parameters

#### Associating or Disassociating a Capture File

```
Device# monitor capture point mycap file location flash:mycap.pcap
Device# no monitor capture mycap file
```

#### Specifying a Memory Buffer Size for Packet Burst Handling

```
Device# monitor capture mycap buffer size 100
```

#### Defining an Explicit Core System Filter to Match Both IPv4 and IPv6

```
Device# monitor capture mycap match any
```

### What to do next

if your capture point contains all of the parameters you want, activate it.

## Deleting Capture Point Parameters

Although listed in sequence, the steps to delete parameters can be executed in any order. You can also delete them in one, two, or several lines. Except for attachment points, which can be multiple, you can delete any parameter.

Follow these steps to delete a capture point's parameters.

### Before you begin

A capture point parameter must be defined before you can use these instructions to delete it.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>no monitor capture</b> { <i>capture-name</i> } <b>match</b> <b>Example:</b> Device# <b>no monitor capture mycap match</b>	Deletes all filters defined on capture point (mycap).
<b>Step 3</b>	<b>no monitor capture</b> { <i>capture-name</i> } <b>limit</b> [ <b>duration</b> ] [ <b>packet-length</b> ] [ <b>packets</b> ] <b>Example:</b> Device# <b>no monitor capture mycap limit</b> <b>duration packet-len</b> Device# <b>no monitor capture mycap limit</b>	Deletes the session time limit and the packet segment length to be retained by Wireshark. It leaves other specified limits in place.  Deletes all limits on Wireshark.
<b>Step 4</b>	<b>no monitor capture</b> { <i>capture-name</i> } <b>file</b> [ <b>location</b> ] [ <b>buffer-size</b> ] <b>Example:</b> Device# <b>no monitor capture mycap file</b> Device# <b>no monitor capture mycap file</b> <b>location</b>	Deletes the file association. The capture point will no longer capture packets. It will only display them.  Deletes the file location association. The file location will no longer be associated with the capture point. However, other defined file association will be unaffected by this action.
<b>Step 5</b>	<b>show monitor capture</b> { <i>capture-name</i> } [ <b>parameter</b> ] <b>Example:</b> Device# <b>show monitor capture mycap</b> <b>parameter</b> <b>monitor capture mycap interface</b> GigabitEthernet1/0/1 in	Displays the capture point parameters that remain defined after your parameter deletion operations. This command can be run at any point in the procedure to see what parameters are associated with a capture point.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

**What to do next**

If your capture point contains all of the parameters you want, activate it.



**Note** If the parameters are deleted when the capture point is active, the switch will show an error "*Capture is active*".

**Deleting a Capture Point**

Follow these steps to delete a capture point.

**Before you begin**

A capture point must be defined before you can use these instructions to delete it. You have to stop the capture point before you can delete it.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>no monitor capture</b> { <i>capture-name</i> } <b>Example:</b> Device# <b>no monitor capture mycap</b>	Deletes the specified capture point (mycap).
<b>Step 3</b>	<b>show monitor capture</b> { <i>capture-name</i> } [ <b>parameter</b> ] <b>Example:</b> Device# <b>show monitor capture mycap parameter</b> Capture mycap does not exist	Displays a message indicating that the specified capture point does not exist because it has been deleted.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**What to do next**

You can define a new capture point with the same name as the one you deleted. These instructions are usually performed when one wants to start over with defining a capture point.

## Activating and Deactivating a Capture Point

Follow these steps to activate or deactivate a capture point.

### Before you begin

A capture point can be activated even if an attachment point and a core system filter have been defined and the associated filename already exists. In such an instance, the existing file will be overwritten.

A capture point with no associated filename can only be activated to display. When the filename is not specified, the packets are captured into the buffer. Live display (display during capture) is available in both file and buffer modes.

If no display filters are specified, packets are not displayed live, and all the packets captured by the core system filter are displayed. The default display mode is brief.



**Note** When using a CAPWAP tunneling interface as an attachment point, core filters are not used, so there is no requirement to define them in this case.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>monitor capture</b> { <i>capture-name</i> } <b>start</b> [ <b>display</b> [ <b>display-filter</b> <i>filter-string</i> ]] [ <b>brief</b>   <b>detailed</b>   <b>dump</b> ] <b>Example:</b> Device# <b>monitor capture mycap start display display-filter "stp"</b>	Activates a capture point and filters the display, so only packets containing "stp" are displayed.
<b>Step 3</b>	<b>monitor capture</b> { <i>capture-name</i> } <b>stop</b> <b>Example:</b> Device# <b>monitor capture name stop</b>	Deactivates a capture point.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b>	Verifies your entries.

	Command or Action	Purpose
	Device# <code>show running-config</code>	
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

### What to do next

While activating and deactivating a capture point, you could encounter a few errors. Here are examples of some of the possible errors.

#### Missing attachment point on activation

```
Switch#monitor capture mycap match any
Switch#monitor capture mycap start
No Target is attached to capture failed to disable provision featurefailed to remove
policyfailed to disable provision featurefailed to remove policyfailed to disable provision
featurefailed to remove policy
Capture statistics collected at software (Buffer):
  Capture duration - 0 seconds
  Packets received - 0
  Packets dropped - 0
  Packets oversized - 0

Unable to activate Capture.
Switch# unable to get action unable to get action unable to get action
Switch#monitor capture mycap interface g1/0/1 both
Switch#monitor capture mycap start
Switch#
*Nov 5 12:33:43.906: %BUFCAP-6-ENABLE: Capture Point mycap enabled.
```

#### Missing filter on activation

```
Switch#monitor capture mycap int g1/0/1 both
Switch#monitor capture mycap start
Filter not attached to capture
Capture statistics collected at software (Buffer):
  Capture duration - 0 seconds
  Packets received - 0
  Packets dropped - 0
  Packets oversized - 0

Unable to activate Capture.
Switch#monitor capture mycap match any
Switch#monitor capture mycap start
Switch#
*Nov 5 12:35:37.200: %BUFCAP-6-ENABLE: Capture Point mycap enabled.
```

#### Attempting to activate a capture point while another one is already active

```
Switch#monitor capture mycap start
PD start invoked while previous run is active Failed to start capture : Wireshark operation
failure
Unable to activate Capture.
Switch#show monitor capture
```

```

Status Information for Capture test
Target Type:
Interface: GigabitEthernet1/0/13, Direction: both
Interface: GigabitEthernet1/0/14, Direction: both
Status : Active
Filter Details:
Capture all packets
Buffer Details:
Buffer Type: LINEAR (default)
Buffer Size (in MB): 10
File Details:
Associated file name: flash:cchh.pcap
Limit Details:
Number of Packets to capture: 0 (no limit)
Packet Capture duration: 0 (no limit)
Packet Size to capture: 0 (no limit)
Maximum number of packets to capture per second: 1000
Packet sampling rate: 0 (no sampling)

Status Information for Capture mycap
Target Type:
Interface: GigabitEthernet1/0/1, Direction: both
Status : Inactive
Filter Details:
Capture all packets
Buffer Details:
Buffer Type: LINEAR (default)
Buffer Size (in MB): 10
File Details:
File not associated
Limit Details:
Number of Packets to capture: 0 (no limit)
Packet Capture duration: 0 (no limit)
Packet Size to capture: 0 (no limit)
Maximum number of packets to capture per second: 1000
Packet sampling rate: 0 (no sampling)
Switch#monitor capture test stop
Capture statistics collected at software (Buffer & Wireshark):
Capture duration - 157 seconds
Packets received - 0
Packets dropped - 0
Packets oversized - 0

Switch#
*Nov 5 13:18:17.406: %BUFCAP-6-DISABLE: Capture Point test disabled.
Switch#monitor capture mycap start
Switch#
*Nov 5 13:18:22.664: %BUFCAP-6-ENABLE: Capture Point mycap enabled.
Switch#

```

## Clearing the Capture Point Buffer

Follow these steps to clear the buffer contents or save them to an external file for storage.




---

**Note** If you have more than one capture that is storing packets in a buffer, clear the buffer before starting a new capture to avoid memory loss. Do not try to clear buffer on an active capture point.

---





**Note** Clearing buffer on an active capture point is supported only on Lan Base as this only clears the content. On all other licenses, it deletes the buffer itself, hence cannot be run during active capture.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>monitor capture</b> { <i>capture-name</i> } [ <b>clear</b>   <b>export</b> <i>filename</i> ] <b>Example:</b> Device# <b>monitor capture mycap clear</b>	<b>Clear</b> - Completely deletes the buffer. <b>Note</b> When the clear command is run, <ul style="list-style-type: none"> <li>• On Lan base - the command clears the buffer contents without deleting the buffer</li> <li>• On all other licenses - the command deletes the buffer itself.</li> </ul> <b>Export</b> - Saves the captured packets in the buffer as well as deletes the buffer.
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 4</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 5</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Examples: Capture Point Buffer Handling****Exporting Capture to a File**

```
Device# monitor capture mycap export flash:mycap.pcap
```

Storage configured as File for this capture

**Clearing Capture Point Buffer**

```
Device# monitor capture mycap clear
```

Capture configured with file options

**What to do next**

**Note** If you try to clear the capture point buffer on licenses other than LAN Base, the switch will show an error "*Failed to clear capture buffer : Capture Buffer BUSY*".

# How to Implement Embedded Packet Capture

## Managing Packet Data Capture



**Note** Export of an active capture point is only supported on LAN Base licence. On all other license we need to stop the capture first and only then export.

To manage Packet Data Capture in the buffer mode, perform the following steps:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>monitor capture</b> <i>capture-name</i> <b>access-list</b> <i>access-list-name</i> <b>Example:</b> Device# <b>monitor capture mycap access-list v4acl</b>	Configures a monitor capture specifying an access list as the core filter for the packet capture.
<b>Step 3</b>	<b>monitor capture</b> <i>capture-name</i> <b>limit duration</b> <i>seconds</i>	Configures monitor capture limits.

	Command or Action	Purpose
	<b>Example:</b>  Device# <code>monitor capture mycap limit duration 1000</code>	
<b>Step 4</b>	<b>monitor capture <i>capture-name</i> interface <i>interface-name</i> both</b>  <b>Example:</b>  Device# <code>monitor capture mycap interface GigabitEthernet 0/0/1 both</code>	Configures monitor capture specifying an attachment point and the packet flow direction.
<b>Step 5</b>	<b>monitor capture <i>capture-name</i> buffer circular <i>size bytes</i></b>  <b>Example:</b>  Device# <code>monitor capture mycap buffer circular size 10</code>	Configures a buffer to capture packet data.
<b>Step 6</b>	<b>monitor capture <i>capture-name</i> start</b>  <b>Example:</b>  Device# <code>monitor capture mycap start</code>	Starts the capture of packet data at a traffic trace point into a buffer.
<b>Step 7</b>	<b>monitor capture <i>capture-name</i> stop</b>  <b>Example:</b>  Device# <code>monitor capture mycap stop</code>	Stops the capture of packet data at a traffic trace point.
<b>Step 8</b>	<b>monitor capture <i>capture-name</i> export <i>file--location/file-name</i></b>  <b>Example:</b>  Device# <code>monitor capture mycap export tftp://10.1.88.9/mycap.pcap</code>	Exports captured data for analysis.
<b>Step 9</b>	<b>end</b>  <b>Example:</b>  Device# <code>end</code>	Returns to privileged EXEC mode.

### What to do next



**Note** If you try to export an active capture point on licenses other than LAN Base, the switch will show an error "Failed to Export : Capture Buffer BUSY".

## Monitoring and Maintaining Captured Data

Perform this task to monitor and maintain the packet data captured. Capture buffer details and capture point details are displayed.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>show monitor capture <i>capture-buffer-name</i> buffer dump</b> <b>Example:</b> Device# <b>show monitor capture mycap buffer dump</b>	(Optional) Displays a hexadecimal dump of captured packet and its metadata.
<b>Step 3</b>	<b>show monitor capture <i>capture-buffer-name</i> parameter</b> <b>Example:</b> Device# <b>show monitor capture mycap parameter</b>	(Optional) Displays a list of commands that were used to specify the capture.
<b>Step 4</b>	<b>debug epc capture-point</b> <b>Example:</b> Device# <b>debug epc capture-point</b>	(Optional) Enables packet capture point debugging.
<b>Step 5</b>	<b>debug epc provision</b> <b>Example:</b> Device# <b>debug epc provision</b>	(Optional) Enables packet capture provisioning debugging.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

# Monitoring Packet Capture

## Configuration Examples for Wireshark

### Example: Displaying a Brief Output from a .pcap File

You can display the output from a .pcap file by entering:

```
Device# show monitor capture file flash:mycap.pcap brief
Starting the packet display ..... Press Ctrl + Shift + 6 to exit

  1 0.000000000  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request  id=0x002e,
seq=0/0, ttl=254
  2 0.000051000  10.10.10.1 -> 10.10.10.2  ICMP 114 Echo (ping) reply   id=0x002e,
seq=0/0, ttl=255 (request in 1)
  3 0.000098000  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request  id=0x002e,
seq=1/256, ttl=254
  4 0.001782000  10.10.10.1 -> 10.10.10.2  ICMP 114 Echo (ping) reply   id=0x002e,
seq=1/256, ttl=255 (request in 3)
  5 0.002961000  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request  id=0x002e,
seq=2/512, ttl=254
  6 0.003676000  10.10.10.1 -> 10.10.10.2  ICMP 114 Echo (ping) reply   id=0x002e,
seq=2/512, ttl=255 (request in 5)
  7 0.004835000  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request  id=0x002e,
seq=3/768, ttl=254
  8 0.005579000  10.10.10.1 -> 10.10.10.2  ICMP 114 Echo (ping) reply   id=0x002e,
seq=3/768, ttl=255 (request in 7)
  9 0.006850000  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request  id=0x002e,
seq=4/1024, ttl=254
 10 0.007586000  10.10.10.1 -> 10.10.10.2  ICMP 114 Echo (ping) reply   id=0x002e,
seq=4/1024, ttl=255 (request in 9)
 11 0.008768000  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request  id=0x002e,
seq=5/1280, ttl=254
 12 0.009497000  10.10.10.1 -> 10.10.10.2  ICMP 114 Echo (ping) reply   id=0x002e,
seq=5/1280, ttl=255 (request in 11)
 13 0.010695000  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request  id=0x002e,
seq=6/1536, ttl=254
 14 0.011427000  10.10.10.1 -> 10.10.10.2  ICMP 114 Echo (ping) reply   id=0x002e,
seq=6/1536, ttl=255 (request in 13)
 15 0.012728000  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request  id=0x002e,
seq=7/1792, ttl=254
 16 0.013458000  10.10.10.1 -> 10.10.10.2  ICMP 114 Echo (ping) reply   id=0x002e,
seq=7/1792, ttl=255 (request in 15)
 17 0.014652000  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request  id=0x002e,
seq=8/2048, ttl=254
 18 0.015394000  10.10.10.1 -> 10.10.10.2  ICMP 114 Echo (ping) reply   id=0x002e,
seq=8/2048, ttl=255 (request in 17)
 19 0.016682000  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request  id=0x002e,
seq=9/2304, ttl=254
 20 0.017439000  10.10.10.1 -> 10.10.10.2  ICMP 114 Echo (ping) reply   id=0x002e,
seq=9/2304, ttl=255 (request in 19)
 21 0.018655000  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request  id=0x002e,
seq=10/2560, ttl=254
 22 0.019385000  10.10.10.1 -> 10.10.10.2  ICMP 114 Echo (ping) reply   id=0x002e,
seq=10/2560, ttl=255 (request in 21)
 23 0.020575000  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request  id=0x002e,
seq=11/2816, ttl=254
```

```
--More<
```

## Example: Displaying Detailed Output from a .pcap File

You can display the detailed .pcap file output by entering:

```
Device# show monitor capture file flash:mycap.pcap detailed
Starting the packet display ..... Press Ctrl + Shift + 6 to exit

Frame 1: 114 bytes on wire (912 bits), 114 bytes captured (912 bits) on interface 0
  Interface id: 0
  Encapsulation type: Ethernet (1)
  Arrival Time: Nov  6, 2015 11:44:48.322497000 UTC
  [Time shift for this packet: 0.000000000 seconds]
  Epoch Time: 1446810288.322497000 seconds
  [Time delta from previous captured frame: 0.000000000 seconds]
  [Time delta from previous displayed frame: 0.000000000 seconds]
  [Time since reference or first frame: 0.000000000 seconds]
  Frame Number: 1
  Frame Length: 114 bytes (912 bits)
  Capture Length: 114 bytes (912 bits)
  [Frame is marked: False]
  [Frame is ignored: False]
  [Protocols in frame: eth:ip:icmp:data]
Ethernet II, Src: Cisco_f3:63:46 (00:e1:6d:f3:63:46), Dst: Cisco_31:f1:c6 (00:e1:6d:31:f1:c6)

  Destination: Cisco_31:f1:c6 (00:e1:6d:31:f1:c6)
    Address: Cisco_31:f1:c6 (00:e1:6d:31:f1:c6)
      .... ..0. .... .. = LG bit: Globally unique address (factory default)
      .... ...0 .... .. = IG bit: Individual address (unicast)
  Source: Cisco_f3:63:46 (00:e1:6d:f3:63:46)
    Address: Cisco_f3:63:46 (00:e1:6d:f3:63:46)
      .... ..0. .... .. = LG bit: Globally unique address (factory default)
      .... ...0 .... .. = IG bit: Individual address (unicast)
  Type: IP (0x0800)
Internet Protocol Version 4, Src: 10.10.10.2 (10.10.10.2), Dst: 10.10.10.1 (10.10.10.1)
  Version: 4
  Header length: 20 bytes
  Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00: Not-ECT (Not ECN-Capable Transport))
    0000 00.. = Differentiated Services Codepoint: Default (0x00)
    .... ..00 = Explicit Congestion Notification: Not-ECT (Not ECN-Capable Transport) (0x00)
  Total Length: 100
  Identification: 0x04ba (1210)
  Flags: 0x00
    0... .... = Reserved bit: Not set
    .0.. .... = Don't fragment: Not set
    ..0. .... = More fragments: Not set
  Fragment offset: 0
  Time to live: 254
  Protocol: ICMP (1)
  Header checksum: 0x8fc8 [validation disabled]
    [Good: False]
    [Bad: False]
  Source: 10.10.10.2 (10.10.10.2)
  Destination: 10.10.10.1 (10.10.10.1)
Internet Control Message Protocol
  Type: 8 (Echo (ping) request)
  Code: 0
  Checksum: 0xe4db [correct]
```

```

Identifier (BE): 46 (0x002e)
Identifier (LE): 11776 (0x2e00)
Sequence number (BE): 0 (0x0000)
Sequence number (LE): 0 (0x0000)
Data (72 bytes)

0000 00 00 00 00 09 c9 8f 77 ab cd ab cd ab cd ab cd .....w.....
0010 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0020 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0030 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0040 ab cd ab cd ab cd ab cd .....
      Data: 0000000009c98f77abcdabcdabcdabcdabcdabcdabcd...
      [Length: 72]

Frame 2: 114 bytes on wire (912 bits), 114 bytes captured (912 bits) on interface 0
Interface id: 0

```

## Example: Displaying a Packet Dump Output from a .pcap File.

You can display the packet dump output by entering:

```

Device# show monitor capture file flash:mycap.pcap dump
Starting the packet display ..... Press Ctrl + Shift + 6 to exit

0000 00 e1 6d 31 f1 c6 00 e1 6d f3 63 46 08 00 45 00 ..m1....m.cF..E.
0010 00 64 04 ba 00 00 fe 01 8f c8 0a 0a 0a 02 0a 0a .d.....
0020 0a 01 08 00 e4 db 00 2e 00 00 00 00 00 00 09 c9 .....
0030 8f 77 ab cd ab cd ab cd ab cd ab cd ab cd ab cd .w.....
0040 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0050 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0060 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0070 ab cd ..

0000 00 e1 6d 31 f1 80 00 e1 6d 31 f1 80 08 00 45 00 ..m1....m1....E.
0010 00 64 04 ba 00 00 ff 01 8e c8 0a 0a 0a 01 0a 0a .d.....
0020 0a 02 00 00 ec db 00 2e 00 00 00 00 00 00 09 c9 .....
0030 8f 77 ab cd ab cd ab cd ab cd ab cd ab cd ab cd .w.....
0040 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0050 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0060 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0070 ab cd ..

0000 00 e1 6d 31 f1 c6 00 e1 6d f3 63 46 08 00 45 00 ..m1....m.cF..E.
0010 00 64 04 bb 00 00 fe 01 8f c7 0a 0a 0a 02 0a 0a .d.....
0020 0a 01 08 00 e4 d7 00 2e 00 01 00 00 00 00 09 c9 .....
0030 8f 7a ab cd ab cd ab cd ab cd ab cd ab cd ab cd .z.....
0040 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....

```

## Example: Displaying Packets from a .pcap File using a Display Filter

You can display the .pcap file packets output by entering:

```

Device# show monitor capture file flash:mycap.pcap display-filter "ip.src == 10.10.10.2"
brief
Starting the packet display ..... Press Ctrl + Shift + 6 to exit

  1 0.000000000 10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x002e,
seq=0/0, ttl=254
  3 0.000908000 10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x002e,
seq=1/256, ttl=254

```

**Example: Displaying the Number of Packets Captured in a .pcap File**

```

 5 0.002961000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x002e,
seq=2/512, ttl=254
 7 0.004835000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x002e,
seq=3/768, ttl=254
 9 0.006850000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x002e,
seq=4/1024, ttl=254
11 0.008768000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x002e,
seq=5/1280, ttl=254
13 0.010695000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x002e,
seq=6/1536, ttl=254
15 0.012728000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x002e,
seq=7/1792, ttl=254
17 0.014652000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x002e,
seq=8/2048, ttl=254
19 0.016682000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x002e,
seq=9/2304, ttl=254
21 0.018655000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x002e,
seq=10/2560, ttl=254
23 0.020575000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x002e,
seq=11/2816, ttl=254

```

**Example: Displaying the Number of Packets Captured in a .pcap File**

You can display the number of packets captured in a .pcap file by entering:

```

Device# show monitor capture file flash:mycap.pcap packet-count
File name:          /flash/mycap.pcap
Number of packets:  50

```

**Example: Displaying a Single Packet Dump from a .pcap File**

You can display a single packet dump from a .pcap file by entering:

```

Device# show monitor capture file flash:mycap.pcap packet-number 10 dump
Starting the packet display ..... Press Ctrl + Shift + 6 to exit

0000 00 e1 6d 31 f1 80 00 e1 6d 31 f1 80 08 00 45 00  ..m1....m1....E.
0010 00 64 04 be 00 00 ff 01 8e c4 0a 0a 0a 01 0a 0a  .d.....
0020 0a 02 00 00 ec ce 00 2e 00 04 00 00 00 00 09 c9  .....
0030 8f 80 ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
0040 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
0050 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
0060 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd  .....
0070 ab cd

```

**Example: Displaying Statistics of Packets Captured in a .pcap File**

You can display the statistics of the packets captured in a .pcap file by entering:

```

Device# show monitor capture file flash:mycap.pcap statistics "h225,counter"
===== H225 Message and Reason Counter =====
RAS-Messages:
Call Signalling:
=====

```

**Example: Simple Capture and Display**

This example shows how to monitor traffic in the Layer 3 interface Gigabit Ethernet 1/0/1:



**Step 1:** Define a capture point to match on the relevant traffic by entering:

```
Device# monitor capture mycap interface GigabitEthernet1/0/3 in
Device# monitor capture mycap match ipv4 any any
Device# monitor capture mycap limit duration 60 packets 50
Device# monitor capture mycap buffer size 100
```

To avoid high CPU utilization, a low packet count and duration as limits has been set.

**Step 2:** Confirm that the capture point has been correctly defined by entering:

```
Device# show monitor capture mycap parameter
      monitor capture mycap interface GigabitEthernet1/0/3 in
      monitor capture mycap match ipv4  any any
      monitor capture mycap buffer size 100
      monitor capture mycap limit packets 50 duration 60
```

```
Device# show monitor capture mycap
Status Information for Capture mycap
Target Type:
  Interface: GigabitEthernet1/0/3, Direction: in
  Status : Inactive
Filter Details:
  IPv4
  Source IP: any
  Destination IP: any
  Protocol: any
Buffer Details:
  Buffer Type: LINEAR (default)
  Buffer Size (in MB): 100
File Details:
  File not associated
Limit Details:
  Number of Packets to capture: 50
  Packet Capture duration: 60
  Packet Size to capture: 0 (no limit)
  Packet sampling rate: 0 (no sampling)
```

**Step 3:** Start the capture process and display the results.

```
Device# monitor capture mycap start display
Starting the packet display ..... Press Ctrl + Shift + 6 to exit

 1  0.000000  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0030, seq=0/0,
    ttl=254
 2  0.003682  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0030,
seq=1/256, ttl=254
 3  0.006586  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0030,
seq=2/512, ttl=254
 4  0.008941  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0030,
seq=3/768, ttl=254
 5  0.011138  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0030,
seq=4/1024, ttl=254
 6  0.014099  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0030,
seq=5/1280, ttl=254
 7  0.016868  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0030,
seq=6/1536, ttl=254
 8  0.019210  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0030,
seq=7/1792, ttl=254
 9  0.024785  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0030,
seq=8/2048, ttl=254
--More--
```

**Step 4:** Delete the capture point by entering:

```
Device# no monitor capture mycap
```



**Note** A **stop** command is not required in this particular case since we have set a limit and the capture will automatically stop once that limit is reached.

For more information on syntax to be used for pcap statistics, refer the "*Additional References*" section.

## Example: Simple Capture and Store

This example shows how to capture packets to a filter:

**Step 1:** Define a capture point to match on the relevant traffic and associate it to a file by entering:

```
Device# monitor capture mycap interface GigabitEthernet1/0/3 in
Device# monitor capture mycap match ipv4 any any
Device# monitor capture mycap limit duration 60 packets 50
Device# monitor capture mycap file location flash:mycap.pcap
```

**Step 2:** Confirm that the capture point has been correctly defined by entering:

```
Device# show monitor capture mycap parameter
  monitor capture mycap interface GigabitEthernet1/0/3 in
  monitor capture mycap match ipv4 any any
  monitor capture mycap file location flash:mycap.pcap
  monitor capture mycap limit packets 50 duration 60
```

```
Device# show monitor capture mycap
```

```
Status Information for Capture mycap
Target Type:
  Interface: GigabitEthernet1/0/3, Direction: in
  Status : Inactive
Filter Details:
  IPv4
  Source IP: any
  Destination IP: any
  Protocol: any
Buffer Details:
  Buffer Type: LINEAR (default)
File Details:
  Associated file name: flash:mycap.pcap
Limit Details:
  Number of Packets to capture: 50
  Packet Capture duration: 60
  Packet Size to capture: 0 (no limit)
  Packet sampling rate: 0 (no sampling)
```

**Step 3:** Launch packet capture by entering:

```
Device# monitor capture mycap start
```

**Step 4:** Display extended capture statistics during runtime by entering:

```
Device# show monitor capture mycap capture-statistics
Capture statistics collected at software:
```

```

Capture duration - 15 seconds
Packets received - 40
Packets dropped - 0
Packets oversized - 0
Packets errored - 0
Packets sent - 40
Bytes received - 7280
Bytes dropped - 0
Bytes oversized - 0
Bytes errored - 0
Bytes sent - 4560

```

**Step 5:** After sufficient time has passed, stop the capture by entering:

```

Device# monitor capture mycap stop
Capture statistics collected at software (Buffer & Wireshark):
Capture duration - 20 seconds
Packets received - 50
Packets dropped - 0
Packets oversized - 0

```



**Note** Alternatively, you could allow the capture operation stop automatically after the time has elapsed or the packet count has been met.

The mycap.pcap file now contains the captured packets.

**Step 6:** Display extended capture statistics after stop by entering:

```

Device# show monitor capture mycap capture-statistics
Capture statistics collected at software:
Capture duration - 20 seconds
Packets received - 50
Packets dropped - 0
Packets oversized - 0
Packets errored - 0
Packets sent - 50
Bytes received - 8190
Bytes dropped - 0
Bytes oversized - 0
Bytes errored - 0
Bytes sent - 5130

```

**Step 7:** Display the packets by entering:

```

Device# show monitor capture file flash:mycap.pcap
Starting the packet display ..... Press Ctrl + Shift + 6 to exit

  1 0.000000000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0031,
seq=0/0, ttl=254
  2 0.002555000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0031,
seq=1/256, ttl=254
  3 0.006199000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0031,
seq=2/512, ttl=254
  4 0.009199000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0031,
seq=3/768, ttl=254
  5 0.011647000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0031,
seq=4/1024, ttl=254
  6 0.014168000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0031,

```

```

seq=5/1280, ttl=254
 7 0.016737000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0031,
seq=6/1536, ttl=254
 8 0.019403000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0031,
seq=7/1792, ttl=254
 9 0.022151000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0031,
seq=8/2048, ttl=254
10 0.024722000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0031,
seq=9/2304, ttl=254
11 0.026890000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0031,
seq=10/2560, ttl=254
12 0.028862000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0031,
seq=11/2816, ttl=254
--More--

```

For more information on syntax to be used for pcap statistics, refer the "*Additional References*" section.

**Step 8:** Delete the capture point by entering:

```
Device# no monitor capture mycap
```

## Example: Using Buffer Capture

This example shows how to use buffer capture:

**Step 1:** Launch a capture session with the buffer capture option by entering:

```

Device# monitor capture mycap interface GigabitEthernet1/0/3 in
Device# monitor capture mycap match ipv4 any any
Device# monitor capture mycap buffer circular size 1
Device# monitor capture mycap start

```

**Step 2:** Determine whether the capture is active by entering:

```

Device# show monitor capture mycap
Status Information for Capture mycap
Target Type:
  Interface: GigabitEthernet1/0/3, Direction: in
  Status : Active
Filter Details:
  IPv4
  Source IP: any
  Destination IP: any
  Protocol: any
Buffer Details:
  Buffer Type: CIRCULAR
  Buffer Size (in MB): 1
File Details:
  File not associated
Limit Details:
  Number of Packets to capture: 0 (no limit)
  Packet Capture duration: 0 (no limit)
  Packet Size to capture: 0 (no limit)
  Maximum number of packets to capture per second: 1000
  Packet sampling rate: 0 (no sampling)

```

**Step 3:** Display extended capture statistics during runtime by entering:

```

Device# show monitor capture mycap capture-statistics
Capture statistics collected at software:
  Capture duration - 88 seconds

```

```

Packets received - 1000
Packets dropped - 0
Packets oversized - 0
Packets errored - 0
Packets sent - 1000
Bytes received - 182000
Bytes dropped - 0
Bytes oversized - 0
Bytes errored - 0
Bytes sent - 114000

```

**Step 4:** Stop the capture by entering:

```

Device# monitor capture mycap stop
Capture statistics collected at software (Buffer):
Capture duration - 2185 seconds
Packets received - 51500
Packets dropped - 0
Packets oversized - 0

```

**Step 5:** Display extended capture statistics after stop by entering:

```

Device# show monitor capture mycap capture-statistics
Capture statistics collected at software:
Capture duration - 156 seconds
Packets received - 2000
Packets dropped - 0
Packets oversized - 0
Packets errored - 0
Packets sent - 2000
Bytes received - 364000
Bytes dropped - 0
Bytes oversized - 0
Bytes errored - 0
Bytes sent - 228000

```

**Step 6:** Determine whether the capture is active by entering:

```

Device# show monitor capture mycap
Status Information for Capture mycap
Target Type:
  Interface: GigabitEthernet1/0/3, Direction: in
  Status : Inactive
Filter Details:
  IPv4
  Source IP: any
  Destination IP: any
  Protocol: any
Buffer Details:
  Buffer Type: CIRCULAR
  Buffer Size (in MB): 1
File Details:
  File not associated
Limit Details:
  Number of Packets to capture: 0 (no limit)
  Packet Capture duration: 0 (no limit)
  Packet Size to capture: 0 (no limit)
  Maximum number of packets to capture per second: 1000
  Packet sampling rate: 0 (no sampling)

```

**Step 7:** Display the packets in the buffer by entering:

## Example: Using Buffer Capture

```

Device# show monitor capture mycap buffer brief
Starting the packet display ..... Press Ctrl + Shift + 6 to exit

  1  0.000000  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0038,
seq=40057/31132,  ttl=254
  2  0.000030  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0038,
seq=40058/31388,  ttl=254
  3  0.000052  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0038,
seq=40059/31644,  ttl=254
  4  0.000073  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0038,
seq=40060/31900,  ttl=254
  5  0.000094  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0038,
seq=40061/32156,  ttl=254
  6  0.000115  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0038,
seq=40062/32412,  ttl=254
  7  0.000137  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0038,
seq=40063/32668,  ttl=254
  8  0.000158  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0038,
seq=40064/32924,  ttl=254
  9  0.000179  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0038,
seq=40065/33180,  ttl=254
 10  0.000200  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0038,
seq=40066/33436,  ttl=254
 11  0.000221  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0038,
seq=40067/33692,  ttl=254
 12  0.000243  10.10.10.2 -> 10.10.10.1  ICMP 114 Echo (ping) request id=0x0038,
seq=40068/33948,  ttl=254
--More--

```

Notice that the packets have been buffered.

**Step 8:** Display the packets in other display modes.

```

Device# show monitor capture mycap buffer detailed
Starting the packet display ..... Press Ctrl + Shift + 6 to exit

Frame 1: 114 bytes on wire (912 bits), 114 bytes captured (912 bits) on interface 0
  Interface id: 0
  Encapsulation type: Ethernet (1)
  Arrival Time: Nov  6, 2015 18:10:06.297972000 UTC
  [Time shift for this packet: 0.000000000 seconds]
  Epoch Time: 1446833406.297972000 seconds
  [Time delta from previous captured frame: 0.000000000 seconds]
  [Time delta from previous displayed frame: 0.000000000 seconds]
  [Time since reference or first frame: 0.000000000 seconds]
  Frame Number: 1
  Frame Length: 114 bytes (912 bits)
  Capture Length: 114 bytes (912 bits)
  [Frame is marked: False]
  [Frame is ignored: False]
  [Protocols in frame: eth:ip:icmp:data]
Ethernet II, Src: Cisco_f3:63:46 (00:e1:6d:f3:63:46), Dst: Cisco_31:f1:c6 (00:e1:6d:31:f1:c6)

  Destination: Cisco_31:f1:c6 (00:e1:6d:31:f1:c6)
  Address: Cisco_31:f1:c6 (00:e1:6d:31:f1:c6)
  .... ..0. .... .. = LG bit: Globally unique address (factory default)
  .... ..0. .... .. = IG bit: Individual address (unicast)
  Source: Cisco_f3:63:46 (00:e1:6d:f3:63:46)
  Address: Cisco_f3:63:46 (00:e1:6d:f3:63:46)
  .... ..0. .... .. = LG bit: Globally unique address (factory default)
  .... ..0. .... .. = IG bit: Individual address (unicast)
  Type: IP (0x0800)
Internet Protocol Version 4, Src: 10.10.10.2 (10.10.10.2), Dst: 10.10.10.1 (10.10.10.1)
Version: 4

```

```

Header length: 20 bytes
Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00: Not-ECT (Not
ECN-Capable Transport))
  0000 00.. = Differentiated Services Codepoint: Default (0x00)
  .... ..00 = Explicit Congestion Notification: Not-ECT (Not ECN-Capable Transport)
(0x00)
Total Length: 100
Identification: 0xabdd (43997)
Flags: 0x00
  0... .... = Reserved bit: Not set
  .0.. .... = Don't fragment: Not set
  ..0. .... = More fragments: Not set
Fragment offset: 0
Time to live: 254
Protocol: ICMP (1)
Header checksum: 0xe8a4 [validation disabled]
  [Good: False]
  [Bad: False]
Source: 10.10.10.2 (10.10.10.2)
Destination: 10.10.10.1 (10.10.10.1)
Internet Control Message Protocol
Type: 8 (Echo (ping) request)
Code: 0
Checksum: 0xa620 [correct]
Identifier (BE): 56 (0x0038)
Identifier (LE): 14336 (0x3800)
Sequence number (BE): 40057 (0x9c79)
Sequence number (LE): 31132 (0x799c)
Data (72 bytes)

0000 00 00 00 00 0b 15 30 63 ab cd ab cd ab cd ab cd .....0c.....
0010 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0020 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0030 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0040 ab cd ab cd ab cd ab cd .....
      Data: 000000000b153063abcdabcdabcdabcdabcdabcdabcd...
      [Length: 72]

```

Frame 2: 114 bytes on wire (912 bits), 114 bytes captured (912 bits) on interface 0

```

Device# show monitor capture mycap buffer dump
Starting the packet display ..... Press Ctrl + Shift + 6 to exit

0000 00 e1 6d 31 f1 c6 00 e1 6d f3 63 46 08 00 45 00 ..m1....m.cF..E.
0010 00 64 ab dd 00 00 fe 01 e8 a4 0a 0a 0a 02 0a 0a .d.....
0020 0a 01 08 00 a6 20 00 38 9c 79 00 00 00 00 0b 15 .....8.y.....
0030 30 63 ab cd ab cd ab cd ab cd ab cd ab cd ab cd 0c.....
0040 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0050 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0060 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0070 ab cd ..

0000 00 e1 6d 31 f1 c6 00 e1 6d f3 63 46 08 00 45 00 ..m1....m.cF..E.
0010 00 64 ab de 00 00 fe 01 e8 a3 0a 0a 0a 02 0a 0a .d.....
0020 0a 01 08 00 a6 1d 00 38 9c 7a 00 00 00 00 0b 15 .....8.z.....
0030 30 65 ab cd ab cd ab cd ab cd ab cd ab cd ab cd 0e.....
0040 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0050 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0060 ab cd ab cd ab cd ab cd ab cd ab cd ab cd ab cd .....
0070 ab cd ..

```

**Step 9:** Clear the buffer by entering:

```
Device# monitor capture mycap clear
```




---

**Note** NOTE - Clearing the buffer deletes the buffer along with the contents.

---




---

**Note** If you require the buffer contents to be displayed, run the clear commands after show commands.

---

**Step 10:** Restart the traffic, wait for 10 seconds, then display the buffer contents by entering:




---

**Note** We cannot run show from buffer during an active capture. Capture should be stopped before running show from buffer. We can however run a show on a pcap file during an active capture in both file and buffer mode. In file mode, we can display the packets in the current capture session's pcap file as well when the capture is active.

---

```
Device# monitor capture mycap start
Switch# show monitor capture mycap

Status Information for Capture mycap
  Target Type:
    Interface: GigabitEthernet1/0/3, Direction: in
    Status : Active
  Filter Details:
    IPv4
    Source IP: any
    Destination IP: any
    Protocol: any
  Buffer Details:
    Buffer Type: CIRCULAR
    Buffer Size (in MB): 1
  File Details:
    File not associated
  Limit Details:
    Number of Packets to capture: 0 (no limit)
    Packet Capture duration: 0 (no limit)
    Packet Size to capture: 0 (no limit)
    Maximum number of packets to capture per second: 1000
    Packet sampling rate: 0 (no sampling)
```

**Step 11:** Stop the packet capture and display the buffer contents by entering:

```
Device# monitor capture mycap stop
Capture statistics collected at software (Buffer):
  Capture duration - 111 seconds
  Packets received - 5000
  Packets dropped - 0
  Packets oversized - 0
```

**Step 12:** Determine whether the capture is active by entering:

```
Device# show monitor capture mycap
Status Information for Capture mycap
  Target Type:
```



```

Interface: GigabitEthernet1/0/3, Direction: in
Status : Inactive
Filter Details:
  IPv4
    Source IP: any
    Destination IP: any
    Protocol: any
Buffer Details:
  Buffer Type: CIRCULAR
  Buffer Size (in MB): 1
File Details:
  File not associated
Limit Details:
  Number of Packets to capture: 0 (no limit)
  Packet Capture duration: 0 (no limit)
  Packet Size to capture: 0 (no limit)
  Maximum number of packets to capture per second: 1000
  Packet sampling rate: 0 (no sampling)

```

### Step 13: Display the packets in the buffer by entering:

```

Device# show monitor capture mycap buffer brief
Starting the packet display ..... Press Ctrl + Shift + 6 to exit

  1 0.000000000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=0/0, ttl=254
  2 0.000030000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=1/256, ttl=254
  3 0.000051000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=2/512, ttl=254
  4 0.000072000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=3/768, ttl=254
  5 0.000093000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=4/1024, ttl=254
  6 0.000114000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=5/1280, ttl=254
  7 0.000136000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=6/1536, ttl=254
  8 0.000157000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=7/1792, ttl=254
  9 0.000178000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=8/2048, ttl=254
 10 0.000199000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=9/2304, ttl=254
 11 0.000220000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=10/2560, ttl=254
 12 0.000241000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=11/2816, ttl=254
--More<

```

### Step 14: Store the buffer contents to the mycap.pcap file in the internal flash: storage device by entering:

```

Device# monitor capture mycap export flash:mycap.pcap
Exported Successfully

```



**Note** The current implementation of export is such that when the command is run, export is "started" but not complete when it returns the prompt to the user. So we have to wait for a message display on the console from Wireshark before it can run a display of packets in the file.

**Step 15:** Display capture packets from the file by entering:

```

Device# show monitor capture file flash:mycap.pcap
Starting the packet display ..... Press Ctrl + Shift + 6 to exit

  1 0.000000000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=0/0, ttl=254
  2 0.000030000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=1/256, ttl=254
  3 0.000051000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=2/512, ttl=254
  4 0.000072000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=3/768, ttl=254
  5 0.000093000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=4/1024, ttl=254
  6 0.000114000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=5/1280, ttl=254
  7 0.000136000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=6/1536, ttl=254
  8 0.000157000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=7/1792, ttl=254
  9 0.000178000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=8/2048, ttl=254
 10 0.000199000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=9/2304, ttl=254
 11 0.000220000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=10/2560, ttl=254
 12 0.000241000 10.10.10.2 -> 10.10.10.1 ICMP 114 Echo (ping) request id=0x0039,
seq=11/2816, ttl=254
--More--

```

**Step 16:** Delete the capture point by entering:

```

Device# no monitor capture mycap

```

**Example: Simple Capture and Store of Packets in Egress Direction**

This example shows how to capture packets to a filter:

**Step 1:** Define a capture point to match on the relevant traffic and associate it to a file by entering:

```

Device# monitor capture mycap interface Gigabit 1/0/1 out match ipv4 any any
Device# monitor capture mycap limit duration 60 packets 100
Device# monitor capture mycap file location flash:mycap.pcap buffer-size 90

```

**Step 2:** Confirm that the capture point has been correctly defined by entering:

```

Device# show monitor capture mycap parameter
monitor capture mycap interface GigabitEthernet1/0/1 out
monitor capture mycap match ipv4 any any
monitor capture mycap file location flash:mycap.pcap buffer-size 90
monitor capture mycap limit packets 100 duration 60

```

```

Device# show monitor capture mycap

```

```

Status Information for Capture mycap
Target Type:
  Interface: GigabitEthernet1/0/1, Direction: out
  Status : Inactive
Filter Details:
  IPv4

```

```

Source IP: any
Destination IP: any
Protocol: any
Buffer Details:
  Buffer Type: LINEAR (default)
File Details:
  Associated file name: flash:mycap.pcap
  Size of buffer(in MB): 90
Limit Details:
  Number of Packets to capture: 100
  Packet Capture duration: 60
  Packet Size to capture: 0 (no limit)
  Packets per second: 0 (no limit)
  Packet sampling rate: 0 (no sampling)

```

### Step 3: Launch packet capture by entering:

```

Device# monitor capture mycap start
A file by the same capture file name already exists, overwrite?[confirm]
Turning on lock-step mode

```

```

Device#
*Oct 14 09:35:32.661: %BUFCAP-6-ENABLE: Capture Point mycap enabled.

```



**Note** Allow the capture operation stop automatically after the time has elapsed or the packet count has been met. When you see the following message in the output, will know that the capture operation has stopped:

```

*Oct 14 09:36:34.632: %BUFCAP-6-DISABLE_ASYNC: Capture Point mycap disabled. Reason : Wireshark Session Ended

```

The mycap.pcap file now contains the captured packets.

### Step 4: Display the packets by entering:

```

Device# show monitor capture file flash:mycap.pcap
Starting the packet display ..... Press Ctrl + Shift + 6 to exit

0.000000  10.1.1.30 -> 20.1.1.2    UDP Source port: 20001  Destination port: 20002
1.000000  10.1.1.31 -> 20.1.1.2    UDP Source port: 20001  Destination port: 20002
2.000000  10.1.1.32 -> 20.1.1.2    UDP Source port: 20001  Destination port: 20002
3.000000  10.1.1.33 -> 20.1.1.2    UDP Source port: 20001  Destination port: 20002
4.000000  10.1.1.34 -> 20.1.1.2    UDP Source port: 20001  Destination port: 20002
5.000000  10.1.1.35 -> 20.1.1.2    UDP Source port: 20001  Destination port: 20002
6.000000  10.1.1.36 -> 20.1.1.2    UDP Source port: 20001  Destination port: 20002
7.000000  10.1.1.37 -> 20.1.1.2    UDP Source port: 20001  Destination port: 20002
8.000000  10.1.1.38 -> 20.1.1.2    UDP Source port: 20001  Destination port: 20002
9.000000  10.1.1.39 -> 20.1.1.2    UDP Source port: 20001  Destination port: 20002

```

### Step 5: Delete the capture point by entering:

```

Device# no monitor capture mycap

```

## Configuration Examples for Embedded Packet Capture

### Example: Managing Packet Data Capture

The following example shows how to manage packet data capture:

```

Device> enable
Device# monitor capture mycap start
Device# monitor capture mycap access-list v4acl
Device# monitor capture mycap limit duration 1000
Device# monitor capture mycap interface GigabitEthernet 0/0/1 both
Device# monitor capture mycap buffer circular size 10
Device# monitor capture mycap start
Device# monitor capture mycap export tftp://10.1.88.9/mycap.pcap
Device# monitor capture mycap stop
Device# end

```

## Example: Monitoring and Maintaining Captured Data

The following example shows how to dump packets in ASCII format:

```

Device# show monitor capture mycap buffer dump
Starting the packet display ..... Press Ctrl + Shift + 6 to exit

0
0000: 01005E00 00020000 0C07AC1D 080045C0 ..^.....E.
0010: 00300000 00000111 CFDC091D 0002E000 .0.....
0020: 000207C1 07C1001C 802A0000 10030AFA .....*.....
0030: 1D006369 73636F00 0000091D 0001 ..example.....

1
0000: 01005E00 0002001B 2BF69280 080046C0 ..^.....+.....F.
0010: 00200000 00000102 44170000 0000E000 . .....D.....
0020: 00019404 00001700 E8FF0000 0000 .....

2
0000: 01005E00 0002001B 2BF68680 080045C0 ..^.....+.....E.
0010: 00300000 00000111 CFDB091D 0003E000 .0.....
0020: 000207C1 07C1001C 88B50000 08030A6E .....n
0030: 1D006369 73636F00 0000091D 0001 ..example.....

3
0000: 01005E00 000A001C 0F2EDC00 080045C0 ..^.....E.
0010: 003C0000 00000258 CE7F091D 0004E000 .<.....X.....
0020: 000A0205 F3000000 00000000 00000000 .....
0030: 00000000 00D10001 000C0100 01000000 .....
0040: 000F0004 00080501 0300

```

The following example shows how to display the list of commands used to configure the capture named mycap:

```

Device# show monitor capture mycap parameter
monitor capture mycap interface GigabitEthernet 1/0/1 both
monitor capture mycap match any
monitor capture mycap buffer size 10
monitor capture mycap limit pps 1000

```

The following example shows how to debug the capture point:

```

Device# debug epc capture-point
EPC capture point operations debugging is on

Device# monitor capture mycap start
*Jun 4 14:17:15.463: EPC CP: Starting the capture cap1
*Jun 4 14:17:15.463: EPC CP: (brief=3, detailed=4, dump=5) = 0
*Jun 4 14:17:15.463: EPC CP: final check before activation
*Jun 4 14:17:15.463: EPC CP: setting up c3pl infra
*Jun 4 14:17:15.463: EPC CP: Setup c3pl acl-class-policy
*Jun 4 14:17:15.463: EPC CP: Creating a class
*Jun 4 14:17:15.464: EPC CP: Creating a class : Successful
*Jun 4 14:17:15.464: EPC CP: class-map Created
*Jun 4 14:17:15.464: EPC CP: creating policy-name epc_policy_cap1
*Jun 4 14:17:15.464: EPC CP: Creating Policy epc_policy_cap1 of type 49 and client type 21

```

```

*Jun 4 14:17:15.464: EPC CP: Storing a Policy
*Jun 4 14:17:15.464: EPC CP: calling ppm_store_policy with epc_policy
*Jun 4 14:17:15.464: EPC CP: Creating Policy : Successful
*Jun 4 14:17:15.464: EPC CP: policy-map created
*Jun 4 14:17:15.464: EPC CP: creating filter for ANY
*Jun 4 14:17:15.464: EPC CP: Adding acl to class : Successful
*Jun 4 14:17:15.464: EPC CP: Setup c3pl class to policy
*Jun 4 14:17:15.464: EPC CP: Attaching Class to Policy
*Jun 4 14:17:15.464: EPC CP: Attaching epc_class_cap1 to epc_policy_cap1
*Jun 4 14:17:15.464: EPC CP: Attaching Class to Policy : Successful
*Jun 4 14:17:15.464: EPC CP: setting up c3pl qos
*Jun 4 14:17:15.464: EPC CP: DBG> Set packet rate limit to 1000
*Jun 4 14:17:15.464: EPC CP: creating action for policy_map epc_policy_cap1 class_map
epc_class_cap1
*Jun 4 14:17:15.464: EPC CP: DBG> Set packet rate limit to 1000
*Jun 4 14:17:15.464: EPC CP: Activating Interface GigabitEthernet1/0/1 direction both
*Jun 4 14:17:15.464: EPC CP: Id attached 0
*Jun 4 14:17:15.464: EPC CP: inserting into active lists
*Jun 4 14:17:15.464: EPC CP: Id attached 0
*Jun 4 14:17:15.465: EPC CP: inserting into active lists
*Jun 4 14:17:15.465: EPC CP: Activating Vlan
*Jun 4 14:17:15.465: EPC CP: Deleting all temp interfaces
*Jun 4 14:17:15.465: %BUFCAP-6-ENABLE: Capture Point cap1 enabled.
*Jun 4 14:17:15.465: EPC CP: Active Capture 1

```

Device# **monitor capture mycap1 stop**

```

*Jun 4 14:17:31.963: EPC CP: Stopping the capture cap1
*Jun 4 14:17:31.963: EPC CP: Warning: unable to unbind capture cap1
*Jun 4 14:17:31.963: EPC CP: Deactivating policy-map
*Jun 4 14:17:31.963: EPC CP: Policy epc_policy_cap1
*Jun 4 14:17:31.964: EPC CP: Deactivating policy-map Successful
*Jun 4 14:17:31.964: EPC CP: removing povision feature
*Jun 4 14:17:31.964: EPC CP: Found action for policy-map epc_policy_cap1 class-map
epc_class_cap1
*Jun 4 14:17:31.964: EPC CP: cleanning up c3pl infra
*Jun 4 14:17:31.964: EPC CP: Removing Class epc_class_cap1 from Policy
*Jun 4 14:17:31.964: EPC CP: Removing Class from epc_policy_cap1
*Jun 4 14:17:31.964: EPC CP: Successfully removed
*Jun 4 14:17:31.964: EPC CP: Removing acl mac from class
*Jun 4 14:17:31.964: EPC CP: Removing acl from class : Successful
*Jun 4 14:17:31.964: EPC CP: Removing all policies
*Jun 4 14:17:31.964: EPC CP: Removing Policy epc_policy_cap1
*Jun 4 14:17:31.964: EPC CP: Removing Policy : Successful
*Jun 4 14:17:31.964: EPC CP: Removing class epc_class_cap1
*Jun 4 14:17:31.965: EPC CP: Removing class : Successful
*Jun 4 14:17:31.965: %BUFCAP-6-DISABLE: Capture Point cap1 disabled.
*Jun 4 14:17:31.965: EPC CP: Active Capture 0

```

The following example shows how to debug the Embedded Packet Capture (EPC) provisioning:

Device# **debug epc provision**

EPC provisionioning debugging is on

Device# **monitor capture mycap start**

```

*Jun 4 14:17:54.991: EPC PROV: No action found for policy-map epc_policy_cap1 class-map
epc_class_cap1
*Jun 4 14:17:54.991: EPC PROV:
*Jun 4 14:17:54.991: Attempting to install service policy epc_policy_cap1
*Jun 4 14:17:54.992: EPC PROV: Attached service policy to epc idb subblock
*Jun 4 14:17:54.992: EPC PROV: Successful. Create feature object
*Jun 4 14:17:54.992: EPC PROV:
*Jun 4 14:17:54.992: Attempting to install service policy epc_policy_cap1
*Jun 4 14:17:54.992: EPC PROV: Successful. Create feature object
*Jun 4 14:17:54.992: %BUFCAP-6-ENABLE: Capture Point cap1 enabled.

```

```

Device# monitor capture mycap stop
*Jun 4 14:18:02.503: EPC PROV: Successful. Remove feature object
*Jun 4 14:18:02.504: EPC PROV: Successful. Remove feature object
*Jun 4 14:18:02.504: EPC PROV: Destroyed epc idb subblock
*Jun 4 14:18:02.504: EPC PROV: Found action for policy-map epc_policy_cap1 class-map
epc_class_cap1
*Jun 4 14:18:02.504: EPC PROV: Deleting EPC action
*Jun 4 14:18:02.504: EPC PROV: Successful. CLASS_REMOVE, policy-map epc_policy_cap1, class
epc_class_cap1
*Jun 4 14:18:02.504: %BUFCAP-6-DISABLE: Capture Point cap1 disabled.

```

## Additional References

### Related Documents

Related Topic	Document Title
Display Filters	For syntax of Display Filters, refer to: <a href="#">Display Filter Reference</a>
Pcap file statistics	For syntax used to display pcap file statistics, refer to "-z" option details at: <a href="#">Tshark Command Reference</a>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### Standards and RFCs

Standard/RFC	Title
None	-

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<p><a href="http://www.cisco.com/support">http://www.cisco.com/support</a></p>







## CHAPTER 77

# Configuring Flexible NetFlow

- [Prerequisites for Flexible NetFlow, on page 1203](#)
- [Restrictions for Flexible NetFlow, on page 1204](#)
- [Information About Flexible Netflow, on page 1206](#)
- [How to Configure Flexible Netflow, on page 1222](#)
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- [Feature Information for Flexible NetFlow, on page 1243](#)

## Prerequisites for Flexible NetFlow

The following are prerequisites for your Flexible NetFlow configuration:

- You must configure a source interface. If you do not configure a source interface, the exporter remains in a disabled state.
- You must configure a valid record name for every flow monitor.
- You must enable IPv6 routing to export the flow records to an IPv6 destination server.
- You must configure IPFIX export protocol for the flow exporter to export netflow records in IPFIX format.
- You are familiar with the Flexible NetFlow key fields as they are defined in the following commands in the Cisco IOS Flexible NetFlow Command Reference:
  - **match datalink**—Datalink (layer2) fields
  - **match flow**—Flow identifying fields
  - **match interface**—Interface fields
  - **match ipv4**—IPv4 fields
  - **match ipv6**—IPv6 fields
  - **match transport**—Transport layer fields
  - **match wireless**—Wireless fields

- **match flow cts**—CTS fields
- You are familiar with the Flexible NetFlow non-key fields as they are defined in the following commands in the Cisco IOS Flexible NetFlow Command Reference :
  - **collect counter**—Counter fields
  - **collect flow**—Flow identifying fields
  - **collect interface**—Interface fields
  - **collect timestamp**—Timestamp fields
  - **collect transport**—Transport layer fields
  - **collect wireless**—Wireless fields

#### IPv4 Traffic

- The networking device must be configured for IPv4 routing.
- One of the following must be enabled on your device and on any interfaces on which you want to enable Flexible NetFlow: Cisco Express Forwarding or distributed Cisco Express Forwarding.

#### IPv6 Traffic

- The networking device must be configured for IPv6 routing.
- One of the following must be enabled on your device and on any interfaces on which you want to enable Flexible NetFlow: Cisco Express Forwarding IPv6 or distributed Cisco Express Forwarding.

## Restrictions for Flexible NetFlow

The following are restrictions for Flexible NetFlow:

- Flexible NetFlow is not supported on the L2 port-channel interface, but is supported on the L2 port-channel member ports.
- Flexible NetFlow is not supported on the L3 port-channel interface, but is supported on the L3 port-channel member ports.
- Traditional NetFlow (TNF) accounting is not supported.
- Flexible NetFlow version 9 and version 10 export formats are supported. However, if you have not configured the export protocol, version 9 export format is applied by default.
- Microflow policing feature shares the NetFlow hardware resource with FNF.
- Only one flow monitor per interface and per direction is supported .
- Layer 2, IPv4, and IPv6 traffic types are supported. Multiple flow monitors of different traffic types can be applied for a given interface and direction. Multiple flow monitors of same traffic type cannot be applied for a given interface and direction.

- Layer 2, VLAN, WLAN and Layer 3 interfaces are supported, but the device does not support SVI and tunnels.
- The following NetFlow table sizes are supported:

Trim Level	Ingress NetFlow Table	Egress NetFlow Table
LAN Base	Not supported	Not supported
IP Base	8 K	16 K
IP Services	8 K	16 K

- Depending on the switch type, a switch will have one or two forwarding ASICs. The capacities listed in the above table are on a per-ASIC basis.
- The switch can support either one or two ASICs. Each ASIC has 8K ingress and 16 K egress entries, whereas each TCAM can handle up to 6K ingress and 12K egress entries.
- The NetFlow tables are on separate compartments and cannot be combined. Depending on which ASIC processed the packet, the flows will be created in the table in the corresponding ASIC.
- NetFlow hardware implementation supports four hardware samplers. You can select a sampler rate from 1 out of 2 to 1 out of 1024. Only random sampling mode is supported.
- With the microflow policing feature (which is enabled only for wireless implementation), NetFlow can and should be used only in full flow mode i.e. NetFlow policing cannot be used. For wireless traffic, applying a sampler is not permitted, as it hinders microflow QoS.
- Only full flow accounting is supported for wireless traffic.
- NetFlow hardware uses hash tables internally. Hash collisions can occur in the hardware. Therefore, in spite of the internal overflow Content Addressable Memory (CAM), the actual NetFlow table utilization could be about 80 percent.
- Depending on the fields that are used for the flow, a single flow could take two consecutive entries. IPv6 flows also take two entries. In these situations, the effective usage of NetFlow entries is half the table size, which is separate from the above hash collision limitation.
- The device supports up to 15 flow monitors.
- SSID-based NetFlow accounting is supported. SSID is treated in a manner similar to an interface. However, certain fields are not supported such as user ID .
- The NetFlow software implementation supports distributed NetFlow export, so the flows are exported from the same device in which the flow was created.
- Ingress flows are present in the ASIC that first received the packets for the flow. Egress flows are present in the ASIC from which the packets actually left the device set up.
- The reported value for the bytes count field (called “bytes long”) is Layer-2-packet-size—18 bytes. For classic Ethernet traffic (802.3), this will be accurate. For all other Ethernet types, this field will not be accurate. Use the "bytes layer2” field, which always reports the accurate Layer 2 packet size. For information about supported Flexible NetFlow fields, see [Supported Flexible NetFlow Fields, on page 1218](#).
- Configuration of IPFIX exporter on an AVC flow monitor is not supported.

- Flexible NetFlow export is not supported on the Ethernet management port, Gi0/0.
- When a flow record has only Source Group Tag (SGT) and Destination Group Tag (DGT) fields (or only either of the two) and if both the values are not applicable, then a flow will still be created with zero values for SGT and DGT. The flow records are expected to include source and destination IP addresses, along with SGT and DGT fields.
- The flow monitor with flow record, that contains the CTS field, cannot be attached on the WLAN (SSID).
- When QoS marked packet is received on an interface which has NetFlow configured on the egress direction, the QoS value of the packet will be captured by the collector. However, when the packet is received on an interface which has NetFlow configured on the ingress direction, the QoS value of the packet will not be captured by the collector.

## Information About Flexible Netflow

### Flexible NetFlow Overview

Flexible NetFlow uses flows to provide statistics for accounting, network monitoring, and network planning.

A flow is a unidirectional stream of packets that arrives on a source interface and has the same values for the keys. A key is an identified value for a field within the packet. You create a flow using a flow record to define the unique keys for your flow.

The device supports the Flexible NetFlow feature that enables enhanced network anomalies and security detection. Flexible NetFlow allows you to define an optimal flow record for a particular application by selecting the keys from a large collection of predefined fields.

All key values must match for the packet to count in a given flow. A flow might gather other fields of interest, depending on the export record version that you configure. Flows are stored in the Flexible NetFlow cache.

You can export the data that Flexible NetFlow gathers for your flow by using an exporter and export this data to a remote system such as a Flexible NetFlow collector. The Flexible NetFlow collector can use an IPv4 or IPv6 address.

You define the size of the data that you want to collect for a flow using a monitor. The monitor combines the flow record and exporter with the Flexible NetFlow cache information.

### Wireless Flexible NetFlow Overview

The wireless Flexible NetFlow infrastructure supports the following:

- Flexible NetFlow Version 9.0 and 10
- User-based rate limiting
- Microflow policing
- Voice and video flow monitoring
- Reflexive access control list (ACL)

#### Microflow Policing and User-Based Rate Limiting

Microflow policing associates a 2-color 1-rate policer and related drop statistics to each flow present in the NetFlow table. When the flow mask comprises all packet fields, this functionality is known as microflow

policing. When the flow mask comprises either source or destination only, this functionality is known as user-based rate limiting.

### Voice and Video Flow Monitoring

Voice and video flows are full flow mask-based entries. The ASIC provides the flexibility to program the policer parameters, share policers across multiple flows and rewrite the IP address and Layer 4 port numbers of these flows.



**Note** For dynamic entries, the NetFlow engine will use the policer parameters that are derived for the flow based on the policy (ACL/QoS-based policies). Dynamic entries cannot share policer across multiple flows.

### Reflexive ACL

Reflexive ACLs allow IP packets to be filtered based on upper-layer session information. The ACLs allow outbound traffic and limit inbound traffic in response to the sessions that originate inside the trusted network. The reflexive ACLs are transparent to the filtering mechanism until a data packet that matches the reflexive entry activates it. At this time, a temporary ACL entry is created and added to the IP-named access lists. The information obtained from the data packet to generate the reflexive ACL entry is permit/deny bit, the source IP address and port, the destination IP address, port, and the protocol type. During reflexive ACL entry evaluation, if the protocol type is either TCP or UDP, then the port information must match exactly. For other protocols, there is no port information to match. After this ACL is installed, the firewall is then opened for the reply packets to pass through. At this time, a potential hacker could have access to the network behind the firewall. To narrow this window, an idle timeout period can be defined. However, in the case of TCP, if two FIN bits or an RST is detected, the ACL entry can be removed.

## Original NetFlow and Benefits of Flexible NetFlow

Original NetFlow uses a fixed seven tuples of IP information to identify a flow.

Flexible NetFlow allows the flow to be user defined. The benefits of Flexible NetFlow include:

- High-capacity flow recognition, including scalability and aggregation of flow information.
- Enhanced flow infrastructure for security monitoring and dDoS detection and identification.
- New information from packets to adapt flow information to a particular service or operation in the network. The flow information available will be customizable by Flexible NetFlow users.
- Extensive use of Cisco's flexible and extensible NetFlow Version 9 and version 10 export formats. With version 10 export format, support for variable length field for the wireless client's SSID is available.
- A comprehensive IP accounting feature that can be used to replace many accounting features, such as IP accounting, Border Gateway Protocol (BGP) Policy Accounting, and persistent caches.
- Support for ingress and egress NetFlow accounting.
- Support for full flow accounting and sampled NetFlow accounting.

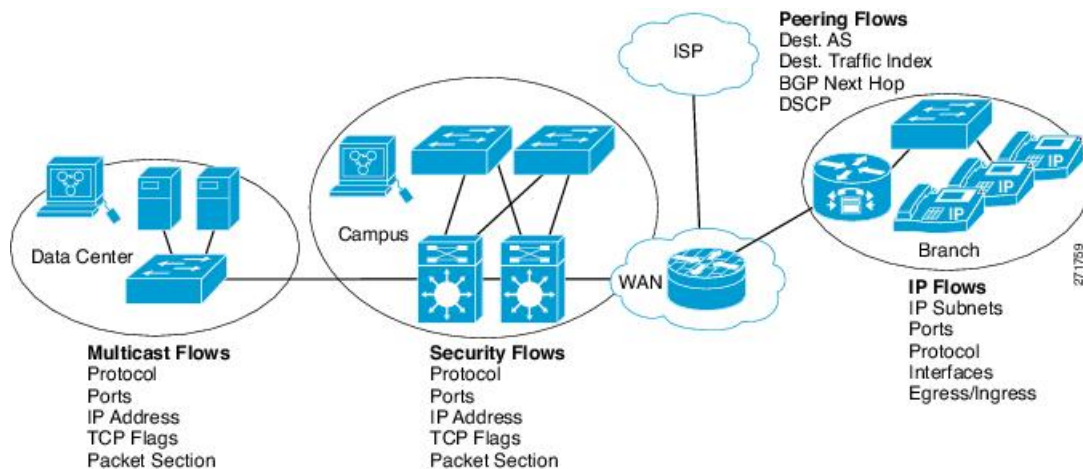
Original NetFlow allows you to understand the activities in the network and thus to optimize network design and reduce operational costs.

Flexible NetFlow allows you to understand network behavior with more efficiency, with specific flow information tailored for various services used in the network. The following are some example applications for a Flexible NetFlow feature:

- Flexible NetFlow enhances Cisco NetFlow as a security monitoring tool. For instance, new flow keys can be defined for packet length or MAC address, allowing users to search for a specific type of attack in the network.
- Flexible NetFlow allows you to quickly identify how much application traffic is being sent between hosts by specifically tracking TCP or UDP applications by the class of service (CoS) in the packets.
- The accounting of traffic entering a Multiprotocol Label Switching (MPLS) or IP core network and its destination for each next hop per class of service. This capability allows the building of an edge-to-edge traffic matrix.

The figure below is an example of how Flexible NetFlow might be deployed in a network.

**Figure 88: Typical Deployment for Flexible NetFlow**



## Flexible NetFlow Components

Flexible NetFlow consists of components that can be used together in several variations to perform traffic analysis and data export. The user-defined flow records and the component structure of Flexible NetFlow facilitates the creation of various configurations for traffic analysis and data export on a networking device with a minimum number of configuration commands. Each flow monitor can have a unique combination of flow record, flow exporter, and cache type. If you change a parameter such as the destination IP address for a flow exporter, it is automatically changed for all the flow monitors that use the flow exporter. The same flow monitor can be used in conjunction with different flow samplers to sample the same type of network traffic at different rates on different interfaces. The following sections provide more information on Flexible NetFlow components:

### Flow Records

In Flexible NetFlow a combination of key and nonkey fields is called a record. Flexible NetFlow records are assigned to Flexible NetFlow flow monitors to define the cache that is used for storing flow data. Flexible NetFlow includes several predefined records that can help you get started using Flexible NetFlow.

A flow record defines the keys that Flexible NetFlow uses to identify packets in the flow, as well as other fields of interest that Flexible NetFlow gathers for the flow. You can define a flow record with any combination of keys and fields of interest. The device supports a rich set of keys. A flow record also defines the types of counters gathered per flow. You can configure 64-bit packet or byte counters. The device enables the following match fields as the defaults when you create a flow record:

- match datalink—Layer 2 attributes
- match flow direction — Specifies a match to the fields identifying the direction of flow.
- match interface—Interface attributes
- match ipv4—IPv4 attributes
- match ipv6—IPv6 attributes
- match transport—Transport layer fields
- match wireless—Wireless fields
- match flow cts—CTS fields

## NetFlow Predefined Records

Flexible NetFlow includes several predefined records that you can use to start monitoring traffic in your network. The predefined records are available to help you quickly deploy Flexible NetFlow and are easier to use than user-defined flow records. You can choose from a list of already defined records that may meet the needs for network monitoring. As Flexible NetFlow evolves, popular user-defined flow records will be made available as predefined records to make them easier to implement.

The predefined records ensure backward compatibility with your existing NetFlow collector configurations for the data that is exported. Each of the predefined records has a unique combination of key and nonkey fields that offer you the built-in ability to monitor various types of traffic in your network without customizing Flexible NetFlow on your router.

Two of the predefined records (NetFlow original and NetFlow IPv4/IPv6 original output), which are functionally equivalent, emulate original (ingress) NetFlow and the Egress NetFlow Accounting feature in original NetFlow, respectively. Some of the other Flexible NetFlow predefined records are based on the aggregation cache schemes available in original NetFlow. The Flexible NetFlow predefined records that are based on the aggregation cache schemes available in original NetFlow do not perform aggregation. Instead each flow is tracked separately by the predefined records.

## User-Defined Records

Flexible NetFlow enables you to define your own records for a Flexible NetFlow flow monitor cache by specifying the key and nonkey fields to customize the data collection to your specific requirements. When you define your own records for a Flexible NetFlow flow monitor cache, they are referred to as *user-defined records*. The values in nonkey fields are added to flows to provide additional information about the traffic in the flows. A change in the value of a nonkey field does not create a new flow. In most cases the values for nonkey fields are taken from only the first packet in the flow. Flexible NetFlow enables you to capture counter values such as the number of bytes and packets in a flow as nonkey fields.

You can create user-defined records for applications such as QoS and bandwidth monitoring, application and end user traffic profiling, and security monitoring for dDoS attacks. Flexible NetFlow also includes several predefined records that emulate original NetFlow. Flexible NetFlow user-defined records provide the capability to monitor a contiguous section of a packet of a user-configurable size, and use it in a flow record as a key or

a nonkey field along with other fields and attributes of the packet. The section may include any Layer 3 data from the packet. The packet section fields allow the user to monitor any packet fields that are not covered by the Flexible NetFlow predefined keys. The ability to analyze packet fields that are not collected with the predefined keys enables more detailed traffic monitoring, facilitates the investigation of dDoS attacks, and enables implementation of other security applications such as URL monitoring.

Flexible NetFlow provides predefined types of packet sections of a user-configurable size. The following Flexible NetFlow commands (used in Flexible NetFlow flow record configuration mode) can be used to configure the predefined types of packet sections:

- **collect ipv4 section header size** *bytes* --Starts capturing the number of bytes specified by the *bytes* argument from the beginning of the IPv4 header of each packet.
- **collect ipv4 section payload size** *bytes* --Starts capturing bytes immediately after the IPv4 header from each packet. The number of bytes captured is specified by the *bytes* argument.
- **collect ipv6 section header size** *bytes* --Starts capturing the number of bytes specified by the *bytes* argument from the beginning of the IPv6 header of each packet.
- **collect ipv6 section payload size** *bytes* --Starts capturing bytes immediately after the IPv6 header from each packet. The number of bytes captured is specified by the *bytes* argument.

The *bytes* values are the sizes in bytes of these fields in the flow record. If the corresponding fragment of the packet is smaller than the requested section size, Flexible NetFlow will fill the rest of the section field in the flow record with zeros. If the packet type does not match the requested section type, Flexible NetFlow will fill the entire section field in the flow record with zeros.

Flexible NetFlow adds a new Version 9 export format field type for the header and packet section types. Flexible NetFlow will communicate to the NetFlow collector the configured section sizes in the corresponding Version 9 export template fields. The payload sections will have a corresponding length field that can be used to collect the actual size of the collected section.

## Flexible NetFlow Match Parameters

The following table describes Flexible NetFlow match parameters. You must configure at least one of the following match parameters for the flow records.

**Table 81: Match Parameters**

Command	Purpose
<b>match datalink</b> {dot1q   ethertype   mac   vlan }	Specifies a match to datalink or Layer 2 fields. The following command options are available: <ul style="list-style-type: none"> <li>• <b>dot1q</b>—Matches to the dot1q field.</li> <li>• <b>ethertype</b>—Matches to the ethertype of the packet.</li> <li>• <b>mac</b>—Matches the source or destination MAC fields.</li> <li>• <b>vlan</b>—Matches to the VLAN that the packet is located on (input or output).</li> </ul>
<b>match flow direction</b>	Specifies a match to the flow identifying fields.



Command	Purpose
<b>match interface</b> { <b>input</b>   <b>output</b> }	Specifies a match to the interface fields. The following command options are available: <ul style="list-style-type: none"> <li>• <b>input</b>—Matches to the input interface.</li> <li>• <b>output</b>—Matches to the output interface.</li> </ul>
<b>match ipv4</b> { <b>destination</b>   <b>protocol</b>   <b>source</b>   <b>tos</b>   <b>ttl</b>   <b>version</b> }	Specifies a match to the IPv4 fields. The following command options are available: <ul style="list-style-type: none"> <li>• <b>destination</b>—Matches to the IPv4 destination address-based fields.</li> <li>• <b>protocol</b>—Matches to the IPv4 protocols.</li> <li>• <b>source</b>—Matches to the IPv4 source address based fields.</li> <li>• <b>tos</b>—Matches to the IPv4 Type of Service fields.</li> <li>• <b>ttl</b>—Matches to the IPv4 Time To Live fields.</li> <li>• <b>version</b>—Matches to the IP version from the IPv4 header.</li> </ul>
<b>match ipv6</b> { <b>destination</b>   <b>hop-limit</b>   <b>protocol</b>   <b>source</b>   <b>traffic-class</b>   <b>version</b> }	Specifies a match to the IPv6 fields. The following command options are available: <ul style="list-style-type: none"> <li>• <b>destination</b>—Matches to the IPv6 destination address-based fields.</li> <li>• <b>hop-limit</b>—Matches to the IPv6 hop limit fields.</li> <li>• <b>protocol</b>—Matches to the IPv6 payload protocol fields.</li> <li>• <b>source</b>—Matches to the IPv6 source address based fields.</li> <li>• <b>traffic-class</b>—Matches to the IPv6 traffic class.</li> <li>• <b>version</b>—Matches to the IP version from the IPv6 header.</li> </ul>

Command	Purpose
<b>match transport</b> {destination-port   igmp   icmp   source-port}	Specifies a match to the Transport Layer fields. The following command options are available: <ul style="list-style-type: none"> <li>• <b>destination-port</b>—Matches to the transport destination port.</li> <li>• <b>icmp</b>—Matches to ICMP fields, including ICMP IPv4 and IPv6 fields.</li> <li>• <b>igmp</b>—Matches to IGMP fields.</li> <li>• <b>source-port</b>—Matches to the transport source port.</li> </ul>
<b>match flow cts</b> {source   destination} group-tag	Specifies a match to the CTS fields support in FNF record. The following command options are available: <ul style="list-style-type: none"> <li>• <b>source</b> —Matches to the source of CTS entering the domain.</li> <li>• <b>destination</b> —Matches to the destination of the CTS leaving the domain.</li> </ul>

### Flexible NetFlow Collect Parameters

The following table describes the Flexible NetFlow collect parameters.

*Table 82: Collect Parameters*

Command	Purpose
<b>collect counter</b> { bytes { layer2 { long }   long }   packets { long } }	Collects the counter fields total bytes and total packets.
<b>collect interface</b> {input   output}	Collects the fields from the input or output interface.
<b>collect timestamp absolute</b> {first   last}	Collects the fields for the absolute time the first packet was seen or the absolute time the most recent packet was last seen (in milliseconds).

Command	Purpose
<b>collect transport tcp flags</b>	Collects the following transport TCP flags: <ul style="list-style-type: none"> <li>• <b>ack</b>—TCP acknowledgement flag</li> <li>• <b>cwr</b>—TCP congestion window reduced flag</li> <li>• <b>ece</b>—TCP ECN echo flag</li> <li>• <b>fin</b>—TCP finish flag</li> <li>• <b>psh</b>—TCP push flag</li> <li>• <b>rst</b>—TCP reset flag</li> <li>• <b>syn</b>—TCP synchronize flag</li> <li>• <b>urg</b>—TCP urgent flag</li> </ul> <p><b>Note</b> On the device, you cannot specify which TCP flag to collect. You can only specify to collect transport TCP flags. All TCP flags will be collected with this command.</p>
<b>collect counter bytes</b>	Configures the number of bytes seen in a flow as a nonkey field and enables collecting the total number of bytes from the flow.
<b>collect counter packets</b>	Configures the number of packets seen in a flow as a nonkey field and enables collecting the total number of packets from the flow.
<b>collect timestamp sys-uptime first</b>	Configures the system uptime for the time the first packet was seen from the flows as a nonkey field and enables collecting time stamps based on the system uptime for the time the first packet was seen from the flows.
<b>collect timestamp sys-uptime last</b>	Configures the system uptime for the time the last packet was seen from the flows as a nonkey field and enables collecting time stamps based on the system uptime for the time the most recent packet was seen from the flows.

## Flow Exporters

Flow exporters export the data in the flow monitor cache to a remote system, such as a server running NetFlow collector, for analysis and storage. Flow exporters are created as separate entities in the configuration. Flow exporters are assigned to flow monitors to provide data export capability for the flow monitors. You can create several flow exporters and assign them to one or more flow monitors to provide several export destinations. You can create one flow exporter and apply it to several flow monitors.

### NetFlow Data Export Format Version 10 (IPFIX)

Internet Protocol Flow Information Export (IPFIX) or version 10 is an Export Protocol that collects and exports predefined or user defined flow records. IPFIX is an IETF standard based on NetFlow version 9. The IPFIX format maintains the same principles of separate templates and records as NetFlow version 9. It supports variable length field for SSID of the wireless clients. For IPFIX exporting protocol, the default destination port is 4739, DSCP value is 0, and TTL is 255.

### NetFlow Data Export Format Version 9

The basic output of NetFlow is a flow record. Several different formats for flow records have evolved as NetFlow has matured. The most recent evolution of the NetFlow export format is known as Version 9. The distinguishing feature of the NetFlow Version 9 export format is that it is template-based. Templates provide an extensible design to the record format, a feature that should allow future enhancements to NetFlow services without requiring concurrent changes to the basic flow-record format. Using templates provides several key benefits:

- Third-party business partners who produce applications that provide collector or display services for NetFlow do not have to recompile their applications each time a new NetFlow feature is added. Instead, they should be able to use an external data file that documents the known template formats.
- New features can be added to NetFlow quickly without breaking current implementations.
- NetFlow is “future-proofed” against new or developing protocols because the Version 9 format can be adapted to provide support for them.

NetFlow Version 9 export format provides the following features and functionality:

- Variable field specification format
- Support for IPv4 or IPv6 destination address export
- More efficient network utilization

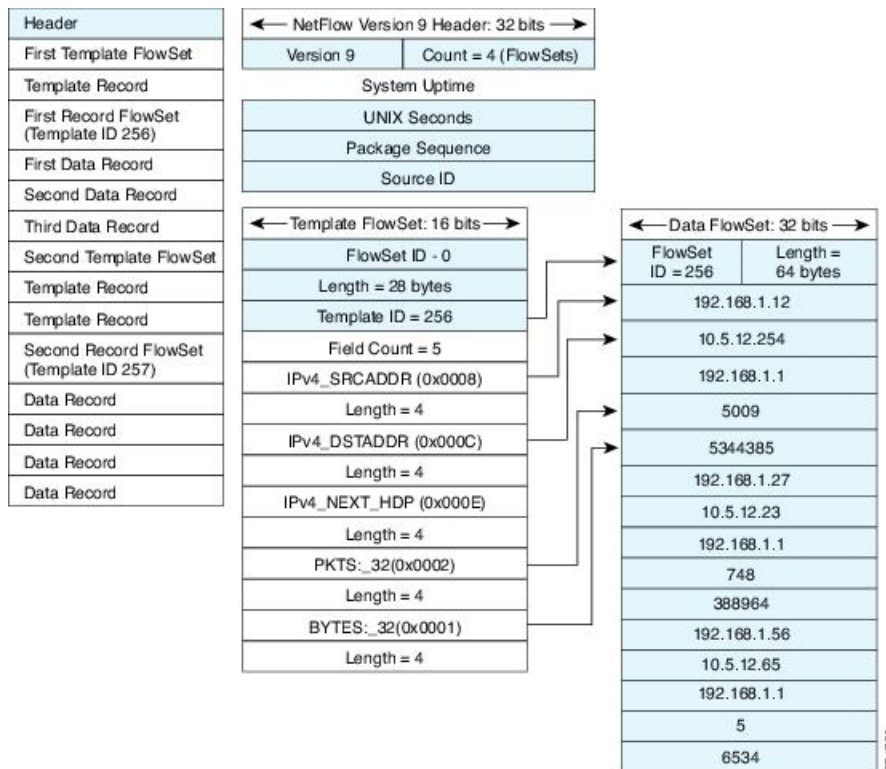
The Version 9 export format consists of a packet header followed by one or more template flow or data flow sets. A template flow set provides a description of the fields that will be present in future data flow sets. These data flow sets may occur later within the same export packet or in subsequent export packets. Template flow and data flow sets can be intermingled within a single export packet, as illustrated in the figure below.

**Figure 89: Version 9 Export Packet**



NetFlow Version 9 will periodically export the template data so the NetFlow collector will understand what data is to be sent and also export the data flow set for the template. The key advantage to Flexible NetFlow is that the user configures a flow record, which is effectively converted to a Version 9 template and then forwarded to the collector. The figure below is a detailed example of the NetFlow Version 9 export format, including the header, template flow, and data flow sets.

Figure 90: Detailed Example of the NetFlow Version 9 Export Format



For more information on the Version 9 export format, refer to the white paper titled [Cisco IOS NetFlow Version 9 Flow-Record Format](http://www.cisco.com/en/US/tech/tk648/tk362/technologies_white_paper09186a00800a3db9.shtml), available at this URL: [http://www.cisco.com/en/US/tech/tk648/tk362/technologies\\_white\\_paper09186a00800a3db9.shtml](http://www.cisco.com/en/US/tech/tk648/tk362/technologies_white_paper09186a00800a3db9.shtml).

## Flow Monitors

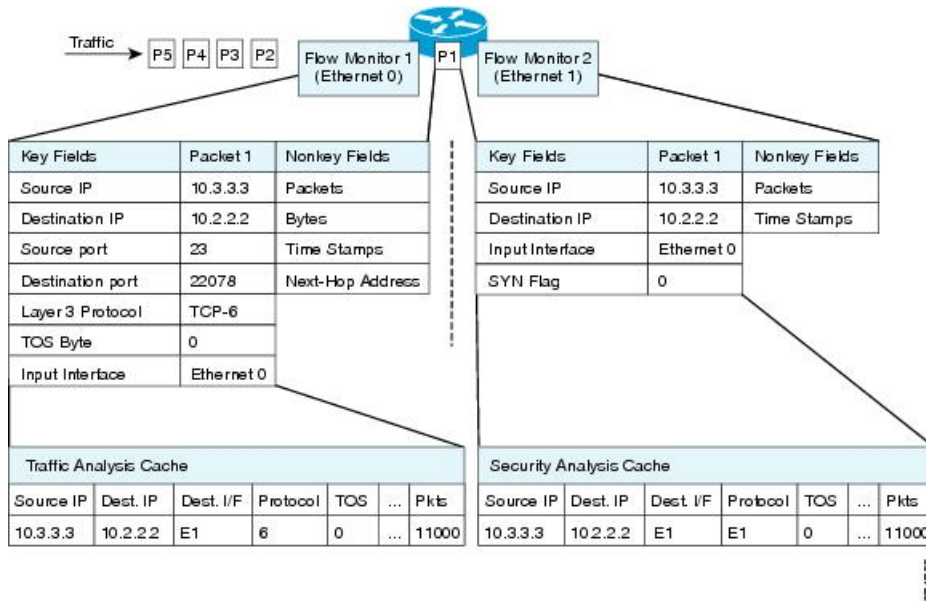
Flow monitors are the Flexible NetFlow component that is applied to interfaces to perform network traffic monitoring.

Flow monitors consist of a user-defined record, an optional flow exporter, and a cache that is automatically created at the time the flow monitor is applied to the first interface.

Flow data is collected from the network traffic and added to the flow monitor cache during the monitoring process based on the key and nonkey fields in the flow record.

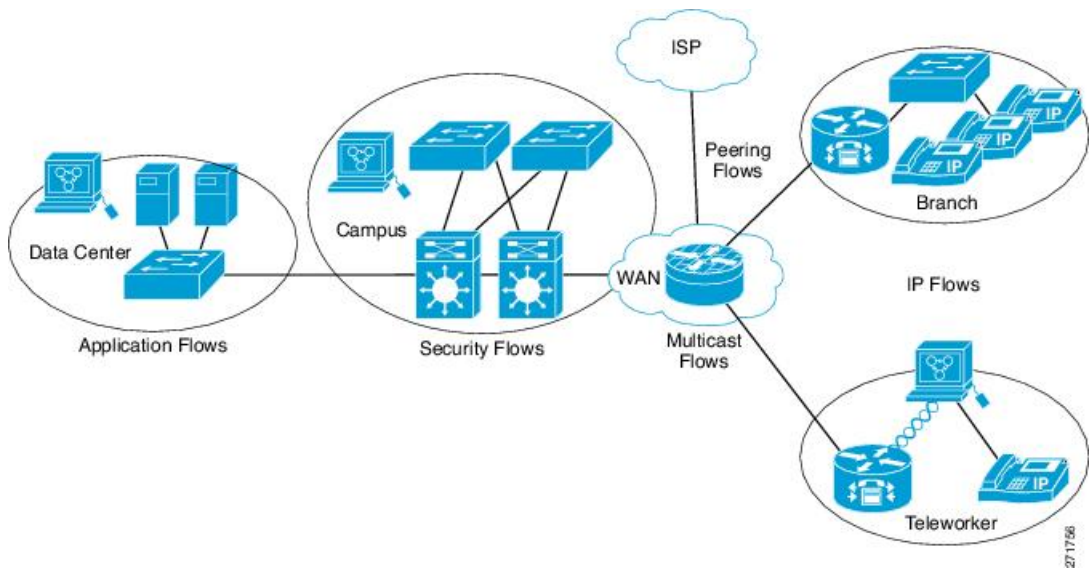
Flexible NetFlow can be used to perform different types of analysis on the same traffic. In the figure below, packet 1 is analyzed using a record designed for standard traffic analysis on the input interface and a record designed for security analysis on the output interface.

Figure 91: Example of Using Two Flow Monitors to Analyze the Same Traffic



The figure below shows a more complex example of how you can apply different types of flow monitors with custom records.

Figure 92: Complex Example of Using Multiple Types of Flow Monitors with Custom Records



There are three types of flow monitor caches. You change the type of cache used by the flow monitor after you create the flow monitor. The three types of flow monitor caches are described in the following sections:

**Normal**

The default cache type is “normal”. In this mode, the entries in the cache are aged out according to the timeout active and timeout inactive settings. When a cache entry is aged out, it is removed from the cache and exported via any exporters configured.

### Immediate

A cache of type "immediate" ages out every record as soon as it is created. As a result, every flow contains just one packet. The commands that display the cache contents will provide a history of the packets seen.

This mode is desirable when you expect only very small flows and you want a minimum amount of latency between seeing a packet and exporting a report.



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**Caution**

This mode may result in a large amount of export data that can overload low-speed links and overwhelm any systems that you are exporting to. We recommend that you configure sampling to reduce the number of packets that are processed.

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**Note**

The cache timeout settings have no effect in this mode.

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### Permanent

A cache of type "permanent" never ages out any flows. A permanent cache is useful when the number of flows you expect to see is low and there is a need to keep long-term statistics on the router. For example, if the only key field in the flow record is the 8-bit IP ToS field, only 256 flows can be monitored. To monitor the long-term usage of the IP ToS field in the network traffic, you can use a permanent cache. Permanent caches are useful for billing applications and for an edge-to-edge traffic matrix for a fixed set of flows that are being tracked. Update messages will be sent periodically to any flow exporters configured according to the "timeout update" setting.



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**Note**

When a cache becomes full in permanent mode, new flows will not be monitored. If this occurs, a "Flows not added" message will appear in the cache statistics.

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**Note**

A permanent cache uses update counters rather than delta counters. This means that when a flow is exported, the counters represent the totals seen for the full lifetime of the flow and not the additional packets and bytes seen since the last export was sent.

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## Flow Samplers

Flow samplers are created as separate components in a router's configuration. Flow samplers are used to reduce the load on the device that is running Flexible NetFlow by limiting the number of packets that are selected for analysis.

Samplers use random sampling techniques (modes); that is, a randomly selected sampling position is used each time a sample is taken.

Flow sampling exchanges monitoring accuracy for router performance. When you apply a sampler to a flow monitor, the overhead load on the router of running the flow monitor is reduced because the number of packets that the flow monitor must analyze is reduced. The reduction in the number of packets that are analyzed by the flow monitor causes a corresponding reduction in the accuracy of the information stored in the flow monitor's cache.

Samplers are combined with flow monitors when they are applied to an interface with the **ip flow monitor** command.

## Supported Flexible NetFlow Fields

The following tables provide a consolidated list of supported fields in Flexible NetFlow (FNF) for various traffic types and traffic direction.



**Note** If the packet has a VLAN field, then that length is not accounted for.

Field	Layer 2 In	Layer 2 Out	IPv4 In	IP v4 Out	IPv6 In	IPv6 Out	Notes
<b>Key or Collect Fields</b>							
Interface input	Yes	—	Yes	—	Yes	—	<p>If you apply a flow monitor in the input direction:</p> <ul style="list-style-type: none"> <li>Use the <b>match</b> keyword and use the input interface as a key field.</li> <li>Use the <b>collect</b> keyword and use the output interface as a collect field. This field will be present in the exported records but with a value of 0.</li> </ul>
Interface output	—	Yes	—	Yes	—	Yes	<p>If you apply a flow monitor in the output direction:</p> <ul style="list-style-type: none"> <li>Use the <b>match</b> keyword and use the output interface as a key field.</li> <li>Use the <b>collect</b> keyword and use the input interface as a collect field. This field will be present in the exported records but with a value of 0.</li> </ul>

Field	Layer 2 In	Layer 2 Out	IPv4 In	IP v4 Out	IPv6 In	IPv6 Out	Notes
<b>Key Fields</b>							



Field	Layer 2 In	Layer 2 Out	IPv4 In	IP v4 Out	IPv6 In	IPv6 Out	Notes
Flow direction	Yes	Yes	Yes	Yes	Yes	Yes	
Ethertype	Yes	Yes	—	—	—	—	
VLAN input	Yes	—	Yes	—	Yes	—	Supported only for a switch port.
VLAN output	—	Yes	—	Yes	—	Yes	Supported only for a switch port.
dot1q VLAN input	Yes	—	Yes	—	Yes	—	Supported only for a switch port.
dot1q VLAN output	—	Yes	—	Yes	—	Yes	Supported only for a switch port.
dot1q priority	Yes	Yes	Yes	Yes	Yes	Yes	Supported only for a switch port.
MAC source address input	Yes	Yes	Yes	Yes	Yes	Yes	
MAC source address output	—	—	—	—	—	—	
MAC destination address input	Yes	—	Yes	—	Yes	—	
MAC destination address output	—	Yes	—	Yes	—	Yes	
IPv4 version	—	—	Yes	Yes	Yes	Yes	
IPv4 TOS	—	—	Yes	Yes	Yes	Yes	

Field	Layer 2 In	Layer 2 Out	IPv4 In	IP v4 Out	IPv6 In	IPv6 Out	Notes
IPv4 protocol	—	—	Yes	Yes	Yes	Yes	Must use if any of src/dest port, ICMP code/type, IGMP type or TCP flags are used.
IPv4 TTL	—	—	Yes	Yes	Yes	Yes	
IPv4 source address	—	—	Yes	Yes	—	—	
IPv4 destination address	—	—	Yes	Yes	—	—	
ICMP IPv4 type	—	—	Yes	Yes	—	—	
ICMP IPv4 code	—	—	Yes	Yes	—	—	
IGMP type	—	—	Yes	Yes	—	—	

Field	Layer 2 In	Layer 2 Out	IPv4 In	IP v4 Out	IPv6 In	IPv6 Out	Notes
<b>Key Fields continued</b>							
IPv6 version	—	—	Yes	Yes	Yes	Yes	Same as IP version.
IPv6 protocol	—	—	Yes	Yes	Yes	Yes	Same as IP protocol. Must use if any of src/dest port, ICMP code/type, IGMP type or TCP flags are used.
IPv6 source address	—	—	—	—	Yes	Yes	

Field	Layer 2 In	Layer 2 Out	IPv4 In	IP v4 Out	IPv6 In	IPv6 Out	Notes
IPv6 destination address	—	—	—	—	Yes	Yes	
IPv6 traffic-class	—	—	Yes	Yes	Yes	Yes	Same as IP TOS.
IPv6 hop-limit	—	—	Yes	Yes	Yes	Yes	Same as IP TTL.
ICMP IPv6 type	—	—	—	—	Yes	Yes	
ICMP IPv6 code	—	—	—	—	Yes	Yes	
source-port	—	—	Yes	Yes	Yes	Yes	
dest-port	—	—	Yes	Yes	Yes	Yes	

Field	Layer 2 In	Layer 2 Out	IPv4 In	IP v4 Out	IPv6 In	IPv6 Out	Notes
<b>Collect Fields</b>							
Bytes long	Yes	Yes	Yes	Yes	Yes	Yes	Packet size = (Ethernet frame size including FCS - 18 bytes) <b>Recommend:</b> Avoid this field and use Bytes layer2 long.
Packets long	Yes	Yes	Yes	Yes	Yes	Yes	
Timestamp absolute first	Yes	Yes	Yes	Yes	Yes	Yes	
Timestamp absolute last	Yes	Yes	Yes	Yes	Yes	Yes	
TCP flags	Yes	Yes	Yes	Yes	Yes	Yes	Collects all flags.

Field	Layer 2 In	Layer 2 Out	IPv4 In	IP v4 Out	IPv6 In	IPv6 Out	Notes
Bytes layer2 long	Yes	Yes	Yes	Yes	Yes	Yes	

## Default Settings

The following table lists the Flexible NetFlow default settings for the device.

*Table 83: Default Flexible NetFlow Settings*

Setting	Default
Flow active timeout	1800 seconds
Flow timeout inactive	15 seconds

## How to Configure Flexible Netflow

To configure Flexible Netflow, follow these general steps:

1. Create a flow record by specifying keys and non-key fields to the flow.
2. Create an optional flow exporter by specifying the protocol and transport destination port, destination, and other parameters.
3. Create a flow monitor based on the flow record and flow exporter.
4. Create an optional sampler.
5. Apply the flow monitor to a Layer 2 port, Layer 3 port, or VLAN.
6. If applicable to your configuration, configure a WLAN to apply a flow monitor to.

## Creating a Customized Flow Record

Perform this task to configure a customized flow record.

Customized flow records are used to analyze traffic data for a specific purpose. A customized flow record must have at least one **match** criterion for use as the key field and typically has at least one **collect** criterion for use as a nonkey field.

There are hundreds of possible permutations of customized flow records. This task shows the steps that are used to create one of the possible permutations. Modify the steps in this task as appropriate to create a customized flow record for your requirements.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>	Enables privileged EXEC mode.

	Command or Action	Purpose
	<b>Example:</b> <pre>Device&gt; enable</pre>	<ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>flow record <i>record-name</i></b> <b>Example:</b> <pre>Device(config)# flow record FLOW-RECORD-1</pre>	Creates a flow record and enters Flexible NetFlow flow record configuration mode. <ul style="list-style-type: none"> <li>• This command also allows you to modify an existing flow record.</li> </ul>
<b>Step 4</b>	<b>description <i>description</i></b> <b>Example:</b> <pre>Device(config-flow-record)# description Used for basic traffic analysis</pre>	(Optional) Creates a description for the flow record.
<b>Step 5</b>	<b>match {ip   ipv6} {destination   source} address</b> <b>Example:</b> <pre>Device(config-flow-record)# match ipv4 destination address</pre>	Configures a key field for the flow record. <b>Note</b> This example configures the IPv4 destination address as a key field for the record. For information about the other key fields available for the <b>match ipv4</b> command, and the other <b>match</b> commands that are available to configure key fields.
<b>Step 6</b>	Repeat Step 5 as required to configure additional key fields for the record.	—
<b>Step 7</b>	<b>match flow cts {source   destination} group-tag</b> <b>Example:</b> <pre>Device(config-flow-record)# match flow cts source group-tag  Device(config-flow-record)# match flow cts destination group-tag</pre>	<b>Note</b> This example configures the CTS source group tag and destination group tag as a key field for the record. For information about the other key fields available for the <b>match ipv4</b> command, and the other <b>match</b> commands that are available to configure key fields.

	Command or Action	Purpose
		<p><b>Note</b></p> <ul style="list-style-type: none"> <li>• Ingress: <ul style="list-style-type: none"> <li>• In an incoming packet, if a header is present, SGT will reflect the same value as the header. If no value is present, it will show zero.</li> <li>• The DGT value will not depend on the ingress port SGACL configuration.</li> </ul> </li> <li>• Egress: <ul style="list-style-type: none"> <li>• If either propagate SGT or CTS is disabled on the egress interface, then SGT will be zero.</li> <li>• In an outgoing packet, if SGACL configuration that corresponds to the (SGT, DGT) exists, DGT will be non-zero.</li> <li>• If SGACL is disabled on the egress port/VLAN or if global SGACL enforcement is disabled, then DGT will be zero</li> </ul> </li> </ul>
<b>Step 8</b>	<b>Example:</b>	<p>Configures the input interface as a nonkey field for the record.</p> <p><b>Note</b> This example configures the input interface as a nonkey field for the record.</p>
<b>Step 9</b>	Repeat the above step as required to configure additional nonkey fields for the record.	—
<b>Step 10</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-flow-record)# end</pre>	Exits Flexible NetFlow flow record configuration mode and returns to privileged EXEC mode.
<b>Step 11</b>	<p><b>show flow record</b> <i>record-name</i></p> <p><b>Example:</b></p>	(Optional) Displays the current status of the specified flow record.

	Command or Action	Purpose
	Device# show flow record FLOW_RECORD-1	
<b>Step 12</b>	<b>show running-config flow record</b> <i>record-name</i>  <b>Example:</b>  Device# show running-config flow record FLOW_RECORD-1	(Optional) Displays the configuration of the specified flow record.

## Creating a Flow Exporter

You can create a flow export to define the export parameters for a flow.



**Note** Each flow exporter supports only one destination. If you want to export the data to multiple destinations, you must configure multiple flow exporters and assign them to the flow monitor.

You can export to a destination using IPv4 or IPv6 address.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>flow exporter</b> <i>name</i>  <b>Example:</b>  Device (config) # <b>flow exporter ExportTest</b>	Creates a flow exporter and enters flow exporter configuration mode. You can also use this command to modify an existing flow exporter.
<b>Step 3</b>	<b>description</b> <i>string</i>  <b>Example:</b>  Device (config-flow-exporter) # <b>description ExportV9</b>	(Optional) Describes this flow record as a maximum 63-character string.
<b>Step 4</b>	<b>destination</b> { <i>ipv4-address</i>   <i>ipv6-address</i> }  <b>Example:</b>  Device (config-flow-exporter) #	Sets the IPv4/IPv6 destination address or hostname for this exporter.

	Command or Action	Purpose
	<pre>destination 192.0.2.1 (IPv4 destination)  Device(config-flow-exporter)# destination 2001:0:0:24::10 (IPv6 destination)</pre>	
<b>Step 5</b>	<p><b>dscp</b> <i>value</i></p> <p><b>Example:</b></p> <pre>Device(config-flow-exporter)# dscp 0</pre>	(Optional) Specifies the differentiated services codepoint value. The range is from 0 to 63. The default is 0.
<b>Step 6</b>	<p><b>source</b> { <i>source type</i> }</p> <p><b>Example:</b></p> <pre>Device(config-flow-exporter)# source gigabitEthernet1/0/1</pre>	<p>(Optional) Specifies the interface to use to reach the NetFlow collector at the configured destination. The following interfaces can be configured as source:</p> <ul style="list-style-type: none"> <li>• <b>Auto Template</b>—Auto-Template interface</li> <li>• <b>Capwap</b>—CAPWAP tunnel interface</li> <li>• <b>GigabitEthernet</b>—Gigabit Ethernet IEEE 802</li> <li>• <b>GroupVI</b>—Group virtual interface</li> <li>• <b>Internal Interface</b>—Internal interface</li> <li>• <b>Loopback</b>—Loopback interface</li> <li>• <b>Null</b>—Null interface</li> <li>• <b>Port-channel</b>—Ethernet Channel of interface</li> <li>• <b>TenGigabitEthernet</b>—10-Gigabit Ethernet</li> <li>• <b>Tunnel</b>—Tunnel interface</li> <li>• <b>Vlan</b>—Catalyst VLANs</li> </ul>
<b>Step 7</b>	<p><b>transport udp</b> <i>number</i></p> <p><b>Example:</b></p> <pre>Device(config-flow-exporter)# transport udp 200</pre>	(Optional) Specifies the UDP port to use to reach the NetFlow collector. The range is from 0 to 65535. For IPFIX exporting protocol, the default destination port is 4739.
<b>Step 8</b>	<p><b>ttl</b> <i>seconds</i></p> <p><b>Example:</b></p>	(Optional) Configures the time-to-live (TTL) value for datagrams sent by the exporter. The



	Command or Action	Purpose
	Device (config-flow-exporter) # <b>ttl 210</b>	range is from 1 to 255 seconds. The default is 255.
<b>Step 9</b>	<b>export-protocol {netflow-v5   netflow-v9   ipfix}</b> <b>Example:</b> Device (config-flow-exporter) # export-protocol netflow-v9	Specifies the version of the NetFlow export protocol used by the exporter. <ul style="list-style-type: none"> <li>• Default: <b>netflow-v9</b>.</li> </ul>
<b>Step 10</b>	<b>end</b> <b>Example:</b> Device (config-flow-record) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 11</b>	<b>show flow exporter [name record-name]</b> <b>Example:</b> Device# <b>show flow exporter ExportTest</b>	(Optional) Displays information about NetFlow flow exporters.
<b>Step 12</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**What to do next**

Define a flow monitor based on the flow record and flow exporter.

## Creating a Customized Flow Monitor

Perform this required task to create a customized flow monitor.

Each flow monitor has a separate cache assigned to it. Each flow monitor requires a record to define the contents and layout of its cache entries. These record formats can be one of the predefined formats or a user-defined format. An advanced user can create a customized format using the **flow record** command.

**Before you begin**

If you want to use a customized record instead of using one of the Flexible NetFlow predefined records, you must create the customized record before you can perform this task. If you want to add a flow exporter to the flow monitor for data export, you must create the exporter before you can complete this task.



**Note** You must use the **no ip flow monitor** command to remove a flow monitor from all of the interfaces to which you have applied it before you can modify the parameters for the **record** command on the flow monitor.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>flow monitor</b> <i>monitor-name</i> <b>Example:</b> Device(config)# flow monitor FLOW-MONITOR-1	Creates a flow monitor and enters Flexible NetFlow flow monitor configuration mode. <ul style="list-style-type: none"> <li>• This command also allows you to modify an existing flow monitor.</li> </ul>
<b>Step 4</b>	<b>description</b> <i>description</i> <b>Example:</b> Device(config-flow-monitor)# description Used for basic ipv4 traffic analysis	(Optional) Creates a description for the flow monitor.
<b>Step 5</b>	<b>record</b> { <i>record-name</i>   <b>netflow-original</b>   <b>netflow</b> { <b>ipv4</b>   <b>ipv6</b> } <i>record</i> [ <b>peer</b> ]} <b>Example:</b> Device(config-flow-monitor)# record FLOW-RECORD-1	Specifies the record for the flow monitor.
<b>Step 6</b>	<b>cache</b> { <b>entries</b> <i>number</i>   <b>timeout</b> { <b>active</b>   <b>inactive</b>   <b>update</b> } <i>seconds</i>   { <b>immediate</b>   <b>normal</b>   <b>permanent</b> }} <b>Example:</b>	The values for the keywords associated with the <b>timeout</b> keyword have no effect when the cache type is set to <b>immediate</b> .  Associates a flow cache with the specified flow monitor.
<b>Step 7</b>	Repeat Step 6 as required to finish modifying the cache parameters for this flow monitor.	—

	Command or Action	Purpose
<b>Step 8</b>	<b>statistics packet protocol</b> <b>Example:</b> <pre>Device(config-flow-monitor)# statistics packet protocol</pre>	(Optional) Enables the collection of protocol distribution statistics for Flexible NetFlow monitors.
<b>Step 9</b>	<b>statistics packet size</b> <b>Example:</b> <pre>Device(config-flow-monitor)# statistics packet size</pre>	(Optional) Enables the collection of size distribution statistics for Flexible NetFlow monitors.
<b>Step 10</b>	<b>exporter exporter-name</b> <b>Example:</b> <pre>Device(config-flow-monitor)# exporter EXPORTER-1</pre>	(Optional) Specifies the name of an exporter that was created previously.
<b>Step 11</b>	<b>end</b> <b>Example:</b> <pre>Device(config-flow-monitor)# end</pre>	Exits Flexible NetFlow flow monitor configuration mode and returns to privileged EXEC mode.
<b>Step 12</b>	<b>show flow monitor [[name] monitor-name [cache [format {csv   record   table}   aggregate   filter   sort]] [statistics]]</b> <b>Example:</b> <pre>Device# show flow monitor FLOW-MONITOR-2 cache</pre>	(Optional) Displays the status and statistics for a Flexible NetFlow flow monitor.
<b>Step 13</b>	<b>show running-config flow monitor monitor-name</b> <b>Example:</b> <pre>Device# show running-config flow monitor FLOW_MONITOR-1</pre>	(Optional) Displays the configuration of the specified flow monitor.
<b>Step 14</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring and Enabling Flow SamplingCreating a Flow Sampler

Perform this required task to configure and enable a flow sampler.



**Note** When you specify the "NetFlow original," or the "NetFlow IPv4 original input," or the "NetFlow IPv6 original input" predefined record for the flow monitor to emulate original NetFlow, the flow monitor can be used only for analyzing input (ingress) traffic.

When you specify the "NetFlow IPv4 original output" or the "NetFlow IPv6 original output" predefined record for the flow monitor to emulate the Egress NetFlow Accounting feature, the flow monitor can be used only for analyzing output (egress) traffic.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>sampler</b> <i>sampler-name</i> <b>Example:</b> Device(config)# sampler SAMPLER-1	Creates a sampler and enters sampler configuration mode. <ul style="list-style-type: none"> <li>• This command also allows you to modify an existing sampler.</li> </ul>
<b>Step 4</b>	<b>description</b> <i>description</i> <b>Example:</b> Device(config-sampler)# description Sample at 50%	(Optional) Creates a description for the flow sampler.
<b>Step 5</b>	<b>mode</b> {random} 1 out-of <i>window-size</i> <b>Example:</b> Device(config-sampler)# mode random 1 out-of 2	Specifies the sampler mode and the flow sampler window size. <ul style="list-style-type: none"> <li>• The range for the <i>window-size</i> argument is from 0 to 1024 to 32768.</li> </ul>
<b>Step 6</b>	<b>exit</b> <b>Example:</b> Device(config-sampler)# exit	Exits sampler configuration mode and returns to global configuration mode.
<b>Step 7</b>	<b>interface</b> <i>type number</i> <b>Example:</b>	Specifies an interface and enters interface configuration mode.

	Command or Action	Purpose
	Device(config)# interface GigabitEthernet 0/0/0	
<b>Step 8</b>	<b>{ip   ipv6} flow monitor <i>monitor-name</i></b> <b>[[sampler] <i>sampler-name</i>] {input   output}</b> <b>Example:</b>  Device(config-if)# ip flow monitor FLOW-MONITOR-1 sampler SAMPLER-1 input	Assigns the flow monitor and the flow sampler that you created to the interface to enable sampling.
<b>Step 9</b>	<b>end</b> <b>Example:</b>  Device(config-if)# end	Exits interface configuration mode and returns to privileged EXEC mode.
<b>Step 10</b>	<b>show sampler <i>sampler-name</i></b> <b>Example:</b>  Device# show sampler SAMPLER-1	Displays the status and statistics of the flow sampler that you configured and enabled.

## Applying a Flow to an Interface

You can apply a flow monitor and an optional sampler to an interface.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>type</i></b> <b>Example:</b>  Device(config)# <b>interface</b> <b>GigabitEthernet1/0/1</b>	Enters interface configuration mode and configures an interface.  Flexible NetFlow is not supported on the L2 port-channel interface, but is supported on the L2 port-channel member ports.  Flexible NetFlow is not supported on the L3 port-channel interface, but is supported on the L3 port-channel member ports.  Command parameters for the interface configuration include:  <ul style="list-style-type: none"> <li>• <b>GigabitEthernet</b>—GigabitEthernet IEEE 802</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>Loopback</b>—Loopback interface</li> <li>• <b>TenGigabitEthernet</b>—10- Gigabit Ethernet</li> <li>• <b>Vlan</b>—Catalyst VLANs</li> <li>• <b>Range</b>—Interface range</li> <li>• <b>WLAN</b>—WLAN interface</li> </ul>
<b>Step 3</b>	<p><b>{ip flow monitor   ipv6 flow monitor} name</b>  <b>[  sampler name] {input}</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# ip flow monitor MonitorTest input</pre>	<p>Associate an IPv4 or an IPv6 flow monitor, and an optional sampler to the interface for input or output packets.</p> <p>You can associate multiple monitors to an interface in both input and output directions.</p>
<b>Step 4</b>	<p><b>{ip flow monitor   ipv6 flow monitor   datalink flow monitor} name [sampler name]</b>  <b>{input   output}</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# ip flow monitor MonitorTest input</pre>	<p>Associate an IPv4, IPv6 and datalink flow monitor, and an optional sampler to the interface for input or output packets.</p> <p>You can associate multiple monitors of different traffic types to an interface in the same direction. However, you cannot associate multiple monitors of same traffic type to an interface in the same direction.</p>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-flow-monitor)# end</pre>	<p>Returns to privileged EXEC mode.</p>
<b>Step 6</b>	<p><b>show flow interface [interface-type number]</b></p> <p><b>Example:</b></p> <pre>Device# show flow interface</pre>	<p>(Optional) Displays information about NetFlow on an interface.</p>
<b>Step 7</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	<p>(Optional) Saves your entries in the configuration file.</p>

## Configuring a Bridged NetFlow on a VLAN

You can apply a flow monitor and an optional sampler to a VLAN.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>vlan [configuration] vlan-id</b> <b>Example:</b>  Device(config)# <code>vlan configuration 30</code> Device(config-vlan-config)#	Enters VLAN or VLAN configuration mode.
<b>Step 3</b>	<b>ip flow monitor monitor name [sampler sampler name] {input   output}</b> <b>Example:</b>  Device(config-vlan-config)# <code>ip flow monitor MonitorTest input</code>	Associates a flow monitor and an optional sampler to the VLAN for input or output packets.
<b>Step 4</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring Layer 2 NetFlow

You can define Layer 2 keys in Flexible NetFlow records that you can use to capture flows in Layer 2 interfaces.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>flow record name</b>	Enters flow record configuration mode.

	Command or Action	Purpose
	<b>Example:</b> Device(config)# <b>flow record L2_record</b> Device(config-flow-record)#	
<b>Step 3</b>	<b>match datalink {dot1q   ethertype   mac   vlan}</b>  <b>Example:</b> Device(config-flow-record)# <b>match datalink ethertype</b>	Specifies the Layer 2 attribute as a key.
<b>Step 4</b>	<b>end</b>  <b>Example:</b> Device(config-flow-record)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show flow record [name ]</b>  <b>Example:</b> Device# <b>show flow record</b>	(Optional) Displays information about NetFlow on an interface.
<b>Step 6</b>	<b>copy running-config startup-config</b>  <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring WLAN to Apply Flow Monitor in Data Link Input/Output Direction

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan [wlan-name { wlan-id SSID_NetworkName   wlan_id }   wlan-name   shutdown]</b>  <b>Example:</b> Device (config) # <b>wlan wlan1</b>	Enters WLAN configuration submenu.  <i>wlan-id</i> is the wireless LAN identifier. The range is 1 to 64.  SSID_NetworkName is the SSID which can contain 32 alphanumeric characters.



	Command or Action	Purpose
		<b>Note</b> If you have already configured this command, enter the <b>wlan wlan-name</b> command.
<b>Step 3</b>	<b>datalink flow monitor monitor-name {input   output}</b> <b>Example:</b>  Device (config-wlan) # <b>datalink flow monitor flow-monitor-1 {input   output}</b>	Applies flow monitor to Layer 2 traffic in the direction of interest.
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show run wlan wlan-name</b> <b>Example:</b>  Device # <b>show wlan mywlan</b>	(Optional) Verifies your configuration.

**Example**

## Configuring WLAN to Apply Flow Monitor in IPV4 and IPv6 Input/Output Direction

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode
<b>Step 2</b>	<b>wlan {wlan-name { wlan-id SSID_NetworkName   wlan_id}   wlan-name   shutdown}</b> <b>Example:</b>  Device (config) # <b>wlan wlan1</b>	Enters WLAN configuration submode.  <i>wlan-id</i> is the wireless LAN identifier. The range is 1 to 64.  SSID_NetworkName is the SSID which can contain 32 alphanumeric characters.  <b>Note</b> If you have already configured this command, enter the <b>wlan wlan-name</b> command.

	Command or Action	Purpose
<b>Step 3</b>	<pre>{ip   ipv6} flow monitor monitor-name {input   output}</pre> <p><b>Example:</b></p> <pre>Device (config-wlan) # ip flow monitor flow-monitor-1 input</pre>	Associates a flow monitor to the WLAN for input or output packets.
<b>Step 4</b>	<pre>end</pre> <p><b>Example:</b></p> <pre>Device (config) # end</pre>	Returns to privileged EXEC mode.
<b>Step 5</b>	<pre>show run wlan wlan-name</pre> <p><b>Example:</b></p> <pre>Device # show wlan mywlan</pre>	(Optional) Verifies your configuration.

### Example

## Monitoring Flexible NetFlow

The commands in the following table can be used to monitor Flexible NetFlow.

**Table 84: Flexible NetFlow Monitoring Commands**

Command	Purpose
<code>show flow exporter [broker   export-ids   name   name   statistics   templates]</code>	Displays information about NetFlow flow exporters and statistics.
<code>show flow exporter [ name exporter-name]</code>	Displays information about NetFlow flow exporters and statistics.
<code>show flow interface</code>	Displays information about NetFlow interfaces.
<code>show flow monitor [ name exporter-name]</code>	Displays information about NetFlow flow monitors and statistics.
<code>show flow monitor statistics</code>	Displays the statistics for the flow monitor
<code>show flow monitor cache format {table   record   csv}</code>	Displays the contents of the cache for the flow monitor, in the format specified.
<code>show flow record [ name record-name]</code>	Displays information about NetFlow flow records.
<code>show sampler [broker   name   name]</code>	Displays information about NetFlow samplers.

# Configuration Examples for Flexible NetFlow

## Example: Configuring a Flow

This example shows how to create a flow and apply it to an interface:

```
Device# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.

Device(config)# flow export export1
Device(config-flow-exporter)# destination 10.0.101.254
Device(config-flow-exporter)# transport udp 2055
Device(config-flow-exporter)# exit
Device(config)# flow record record1
Device(config-flow-record)# match ipv4 source address
Device(config-flow-record)# match ipv4 destination address
Device(config-flow-record)# match ipv4 protocol
Device(config-flow-record)# match transport source-port
Device(config-flow-record)# match transport destination-port
Device(config-flow-record)# match flow cts source group-tag
Device(config-flow-record)# match flow cts destination group-tag
Device(config-flow-record)# collect counter byte long
Device(config-flow-record)# collect counter packet long
Device(config-flow-record)# collect timestamp absolute first
Device(config-flow-record)# collect timestamp absolute last
Device(config-flow-record)# exit
Device(config)# flow monitor monitor1
Device(config-flow-monitor)# record record1
Device(config-flow-monitor)# exporter export1
Device(config-flow-monitor)# exit
Device(config)# interface tenGigabitEthernet 1/0/1
Device(config-if)# ip flow monitor monitor1 input
Device(config-if)# end
```

## Example: Monitoring IPv4 ingress traffic

This example shows how to monitor IPv4 ingress traffic (int g1/0/11 sends traffic to int g1/0/36 and int g3/0/11).

```
Device# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Device(config)# flow record fr-1
Device(config-flow-record)# match ipv4 source address
Device(config-flow-record)# match ipv4 destination address
Device(config-flow-record)# match interface input
Device(config-flow-record)# collect counter bytes long
Device(config-flow-record)# collect counter packets long
Device(config-flow-record)# collect timestamp absolute first
Device(config-flow-record)# collect timestamp absolute last
Device(config-flow-record)# collect counter bytes layer2 long
Device(config-flow-record)# exit
```

```

Device(config)# flow exporter fe-ipfix6
Device(config-flow-exporter)# destination 2001:0:0:24::10
Device(config-flow-exporter)# source Vlan106
Device(config-flow-exporter)# transport udp 4739
Device(config-flow-exporter)# export-protocol ipfix
Device(config-flow-exporter)# template data timeout 240
Device(config-flow-exporter)# exit

Device(config)# flow exporter fe-ipfix
Device(config-flow-exporter)# description IPFIX format collector 100.0.0.80
Device(config-flow-exporter)# destination 100.0.0.80
Device(config-flow-exporter)# dscp 30
Device(config-flow-exporter)# ttl 210
Device(config-flow-exporter)# transport udp 4739
Device(config-flow-exporter)# export-protocol ipfix
Device(config-flow-exporter)# template data timeout 240
Device(config-flow-exporter)# exit

Device(config)# flow exporter fe-1
Device(config-flow-exporter)# destination 10.5.120.16
Device(config-flow-exporter)# source Vlan105
Device(config-flow-exporter)# dscp 32
Device(config-flow-exporter)# ttl 200
Device(config-flow-exporter)# transport udp 2055

Device(config-flow-exporter)# template data timeout 240
Device(config-flow-exporter)# exit

Device(config)# flow monitor fm-1
Device(config-flow-monitor)# exporter fe-ipfix6
Device(config-flow-monitor)# exporter fe-ipfix
Device(config-flow-monitor)# exporter fe-1
Device(config-flow-monitor)# cache timeout inactive 60
Device(config-flow-monitor)# cache timeout active 180
Device(config-flow-monitor)# record fr-1
Device(config-flow-monitor)# end

Device# show running-config interface g1/0/11
Device# show running-config interface g1/0/36
Device# show running-config interface g3/0/11
Device# show flow monitor fm-1 cache format table

```

## Example: Monitoring IPv4 egress traffic

```

Device# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Device(config)# flow record fr-1 out
Device(config-flow-record)# match ipv4 source address
Device(config-flow-record)# match ipv4 destination address
Device(config-flow-record)# match interface output
Device(config-flow-record)# collect counter bytes long
Device(config-flow-record)# collect counter packets long
Device(config-flow-record)# collect timestamp absolute first
Device(config-flow-record)# collect timestamp absolute last
Device(config-flow-record)# exit

Device(config)# flow exporter fe-1
Device(config-flow-exporter)# destination 10.5.120.16

```

```

Device(config-flow-exporter)# source Vlan105
Device(config-flow-exporter)# dscp 32
Device(config-flow-exporter)# ttl 200
Device(config-flow-exporter)# transport udp 2055
Device(config-flow-exporter)# template data timeout 240
Device(config-flow-exporter)# exit

Device(config)# flow exporter fe-ipfix6
Device(config-flow-exporter)# destination 2001:0:0:24::10
Device(config-flow-exporter)# source Vlan106
Device(config-flow-exporter)# transport udp 4739
Device(config-flow-exporter)# export-protocol ipfix
Device(config-flow-exporter)# template data timeout 240
Device(config-flow-exporter)# exit

Device(config)# flow exporter fe-ipfix
Device(config-flow-exporter)# description IPFIX format collector 100.0.0.80
Device(config-flow-exporter)# destination 100.0.0.80
Device(config-flow-exporter)# dscp 30
Device(config-flow-exporter)# ttl 210
Device(config-flow-exporter)# transport udp 4739
Device(config-flow-exporter)# export-protocol ipfix
Device(config-flow-exporter)# template data timeout 240
Device(config-flow-exporter)# exit

Device(config)# flow monitor fm-1-output
Device(config-flow-monitor)# exporter fe-1
Device(config-flow-monitor)# exporter fe-ipfix6
Device(config-flow-monitor)# exporter fe-ipfix
Device(config-flow-monitor)# cache timeout inactive 50
Device(config-flow-monitor)# cache timeout active 120
Device(config-flow-monitor)# record fr-1-out
Device(config-flow-monitor)# end

Device# show flow monitor fm-1-output cache format table

```

## Example: Configuring IPv4 Flexible NetFlow in WLAN (Ingress Direction)

The following example shows how to configure IPv4 Flexible NetFlow on WLAN ingress direction:

```

flow record WLAN-FLOW07
description Working AP mac
match datalink mac source address input
match ipv4 tos
match ipv4 protocol
match ipv4 source address
match ipv4 destination address
match wireless ssid
collect counter bytes long
collect counter packets long
collect wireless ap mac address
flow monitor WLAN-FLOW07
exporter wlan-export
cache timeout inactive 30
cache timeout active 10
record WLAN-FLOW07
wlan CC0506-CC0404
ip flow monitor WLAN-FLOW07 input

Device#show flow monitor WLAN-FLOW07 cache

```

```

Cache type: Normal (Platform cache)
Cache size: Unknown
Current entries: 6

Flows added: 276
Flows aged: 270

    Active timeout ( 10 secs) 257
    Inactive timeout ( 30 secs) 13

DATALINK MAC SOURCE ADDRESS INPUT: 3CA9.F421.4E34
IPV4 SOURCE ADDRESS: 192.168.11.1
IPV4 DESTINATION ADDRESS: 10.29.5.6
WIRELESS SSID: CC0506-CC0404
IP TOS: 0x00
IP PROTOCOL: 6
counter bytes long: 66
counter packets long: 1
wireless ap mac address: B0AA.778E.EB60

```

## Example: Configuring IPv6 and Transport Flag Flexible NetFlow in WLAN (Egress Direction)

The following example shows how to configure IPv6 and transport flag Flexible NetFlow on WLAN egress direction:

```

Device# configure terminal
Device(config)# flow record fr_v6
Device(config-flow-record)# match ipv6 destination address
Device(config-flow-record)# match ipv6 source address
Device(config-flow-record)# match ipv6 hop-limit
Device(config-flow-record)# match ipv6 protocol
Device(config-flow-record)# match ipv6 traffic
Device(config-flow-record)# match ipv6 version
Device(config-flow-record)# match wireless ssid
Device(config-flow-record)# collect wireless ap mac address
Device(config-flow-record)# collect counter bytes long
Device(config-flow-record)# collect transport tcp flags
Device(config-flow-record)# exit

Device(config)# flow monitor fm_v6
Device(config-flow-monitor)# record fr_v6
Device(config-flow-monitor)# exit

Device(config)# wlan wlan_1
Device(config-wlan)# ipv6 flow monitor fm_v6 out
Device(config-wlan)# end

Device# show flow monitor fm_v6 cache

```




---

**Note** On the device, you cannot specify which TCP flag to collect. You can only specify to collect transport TCP flags.

---

## Example: Configuring IPv6 Flexible NetFlow in WLAN (Both Ingress and Egress Directions)

The following example shows how to configure IPv6 Flexible NetFlow on WLAN in both directions:

```
Device# configure terminal
Device (config)# flow record fr_v6
Device (config-flow-record)# match ipv6 destination address
Device (config-flow-record)# match ipv6 source address
Device (config-flow-record)# match ipv6 hop-limit
Device (config-flow-record)# match ipv6 protocol
Device (config-flow-record)# match ipv6 traffic
Device (config-flow-record)# match ipv6 version
Device (config-flow-record)# match wireless ssid
Device (config-flow-record)# collect wireless ap mac address
Device (config-flow-record)# collect counter packets long
Device (config-flow-record)# exit

Device (config)# flow monitor fm_v6
Device (config-flow-monitor)# record fr_v6
Device (config-flow-monitor)# exit

Device (config)# wlan wlan_1
Device (config-wlan)# ipv6 flow monitor fm_v6 in
Device (config-wlan)# ipv6 flow monitor fm_v6 out
Device (config-wlan)# end

Device# show flow monitor fm_v6 cache
```

## Example: Monitoring wireless ingress traffic

```
Device# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Device(config)# flow record fr-wlan-input
Device(config-flow-record)# match datalink mac source address input
Device(config-flow-record)# match datalink mac destination address input
Device(config-flow-record)# match ipv4 source address
Device(config-flow-record)# match ipv4 destination address
Device(config-flow-record)# match wireless ssid
Device(config-flow-record)# collect counter bytes long
Device(config-flow-record)# collect counter packets long
Device(config-flow-record)# collect timestamp absolute first
Device(config-flow-record)# collect timestamp absolute last
Device(config-flow-record)# exit

Device(config)# flow exporter fe-ipfix
Device(config-flow-exporter)# description IPFIX format collector 100.0.0.80
Device(config-flow-exporter)# destination 100.0.0.80
Device(config-flow-exporter)# dscp 30
Device(config-flow-exporter)# ttl 210
Device(config-flow-exporter)# transport udp 4739
Device(config-flow-exporter)# export-protocol ipfix
Device(config-flow-exporter)# template data timeout 240
Device(config-flow-exporter)# exit
```

```

Device(config)# flow exporter fe-ipfix6
Device(config-flow-exporter)# destination 2001:0:0:24::10
Device(config-flow-exporter)# source Vlan106
Device(config-flow-exporter)# transport udp 4739
Device(config-flow-exporter)# export-protocol ipfix
Device(config-flow-exporter)# template data timeout 240
Device(config-flow-exporter)# exit

Device(config)# flow monitor fm-wlan-input
Device(config-flow-monitor)# exporter fe-ipfix
Device(config-flow-monitor)# exporter fe-ipfix6
Device(config-flow-monitor)# cache timeout inactive 30
Device(config-flow-monitor)# cache timeout active 180
Device(config-flow-monitor)# record fr-wlan-input
Device(config-flow-monitor)# end

Device# show running-config wlan nfl_1
Device# show flow monitor fm-wlan-input cache format table

```

## Additional References for NetFlow

### Related Documents

Related Topic	Document Title
Flexible NetFlow CLI Commands	<i>Cisco Flexible NetFlow Command Reference (Catalyst 3850 Switches)</i> <i>Flexible NetFlow Command Reference, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### Standards and RFCs

Standard/RFC	Title
RFC 3954	Cisco Systems NetFlow Services Export Version 9



**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for Flexible NetFlow

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.
Cisco IOS XE 3.3SE	<p>The following new commands were added:</p> <ul style="list-style-type: none"> <li>• <b>match wireless ssid</b></li> <li>• <b>collect wireless ap mac address</b></li> </ul>





## PART **XIII**

# Network Powered Lighting

- [Configuring COAP Proxy Server, on page 1247](#)
- [Configuring Auto SmartPorts, on page 1261](#)
- [Configuring 2-event Classification, on page 1267](#)
- [Configuring Perpetual and Fast POE, on page 1269](#)
- [Frequently Asked Questions, on page 1275](#)





## CHAPTER 78

# Configuring COAP Proxy Server

- [Finding Feature Information, on page 1247](#)
- [Information About the COAP Proxy Server, on page 1247](#)
- [Restrictions for the COAP Proxy Server, on page 1248](#)
- [Supported Hardware for the COAP Proxy Server, on page 1248](#)
- [How to Configure the COAP Proxy Server, on page 1250](#)
- [Monitoring COAP Proxy Server, on page 1254](#)
- [Examples: Configuring the COAP Proxy Server, on page 1255](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About the COAP Proxy Server

The COAP protocol is designed for use with constrained devices. COAP works in the same way on constrained devices as HTTP works on servers in accessing information.

The comparison of COAP and HTTP is shown below:

- In the case of a webservice: **HTTP** is the protocol; **TCP** is the transport; and **HTML** is the most common information format transported.
- In case of a constrained device: **COAP** is the protocol; **UDP** is the transport; and **JSON/link-format/CBOR** is the popular information format.

COAP provides a means to access and control device using a similar **GET/POST** metaphor and restful API as in HTTP.

### Related Topics

- [Configuring the COAP Proxy, on page 1250](#)

[Examples: Configuring the COAP Proxy Server](#), on page 1255

## Restrictions for the COAP Proxy Server

The following restrictions apply to COAP proxy server:

- Switch cannot advertise itself as CoAP client using ipv6 broadcast (CSCUw26467).
- Support for Observe Not Implemented.
- Blockwise requests are not supported. We handle block-wise responses and can generate block-wise responses.
- DTLS Support is for the following modes only RawPublicKey and Certificate Based.
- Switch does not act as DTLS client. DTLS for endpoints only.
- Endpoints are expected to handle and respond with CBOR payloads.
- Client side requests are expected to be in JSON.
- Switch cannot advertise itself to other Resource Directories as IPv6, due to an IPv6 broadcast issue.
- Configuration of Fast PoE, Perpetual PoE or 2-event classification has to be done before physically connecting any endpoint. Alternatively do a manual shut/no-shut of the ports drawing power.
- Power to the ports will be interrupted in case of MCU firmware upgrade and ports will be back up immediately after the upgrade.

## Supported Hardware for the COAP Proxy Server

COAP Proxy Server is supported on the following Catalyst 3850 Switch Models:

Switch Model	Cisco IOS Image	Description
WS-C3850-24T-S	IP Base	Cisco Catalyst 3850 Stackable 24 10/100/1000 Ethernet ports, with 350-WAC power supply 1 RU, IP Base feature set
WS-C3850-48T-S	IP Base	Cisco Catalyst 3850 Stackable 48 10/100/1000 Ethernet ports, with 350-WAC power supply 1 RU, IP Base feature set
WS-C3850-24P-S	IP Base	Cisco Catalyst 3850 Stackable 24 10/100/1000 Ethernet PoE+ ports, with 715-WAC power supply 1 RU, IP Base feature set
WS-C3850-48P-S	IP Base	Cisco Catalyst 3850 Stackable 48 10/100/1000 Ethernet PoE+ ports, with 715-WAC power supply 1 RU, IP Base feature set
WS-C3850-48F-S	IP Base	Cisco Catalyst 3850 Stackable 48 10/100/1000 Ethernet PoE+ ports, with 1100-WAC power supply 1 RU, IP Base feature set
WS-C3850-24U-S	IP Base	Stackable 24 10/100/1000 Cisco UPOE ports, 1 network module slot, 1100 W power supply

Switch Model	Cisco IOS Image	Description
WS-C3850-48U-S	IP Base	Stackable 48 10/100/1000 Cisco UPOE ports, 1 network module slot, 1100 W power supply
WS-C3850-12S-S	IP Base	Stackable 12 SFP module slots, 1 network module slot, 350-W power supply
WS-C3850-24S-S	IP Base	Stackable 24 SFP module slots, 1 network module slot, 350-W power supply
WS-C3850-12XS-S	IP Base	Catalyst 3850 12-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 350 W power supply
WS-C3850-16XS-S	IP Base	Catalyst 3850 16-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 350 W power supply.  16 ports are available when the C3850-NM-4-10G network module is plugged into the WS-C3850-12XS-S switch.
WS-C3850-24XS-S	IP Base	Catalyst 3850 24-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 715 W power supply.
WS-C3850-32XS-S	IP Base	Catalyst 3850 32-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 715 W power supply.  32 ports are available when the C3850-NM-8-10G network module is plugged into the WS-C3850-24XS-S switch.
WS-C3850-48XS-S	IP Base	Stackable, with SFP+ transceivers, 48 ports that support up to 10 G, and 4 ports that support up to 40 G. 750 W power supply.
WS-C3850-48XS-FS	IP Base	Stackable, with SFP+ transceivers, 48 ports that support up to 10 G, and 4 ports that support up to 40 G. 750 W power supply.
WS-C3850-24XU-S	IP Base	Stackable 24 100M/1G/2.5G/5G/10G UPoE ports, 1 network module slot, 1100-W power supply.
WS-C3850-24T-E	IP Services	Cisco Catalyst 3850 Stackable 24 10/100/1000 Ethernet ports, with 350-WAC power supply 1 RU, IP Services feature set
WS-C3850-48T-E	IP Services	Cisco Catalyst 3850 Stackable 48 10/100/1000 Ethernet ports, with 350-WAC power supply 1 RU, IP Services feature set
WS-C3850-24P-E	IP Services	Cisco Catalyst 3850 Stackable 24 10/100/1000 Ethernet PoE+ ports, with 715-WAC power supply 1 RU, IP Services feature set
WS-C3850-48P-E	IP Services	Cisco Catalyst 3850 Stackable 48 10/100/1000 Ethernet PoE+ ports, with 715-WAC power supply 1 RU, IP Services feature set
WS-C3850-48F-E	IP Services	Cisco Catalyst 3850 Stackable 48 10/100/1000 Ethernet PoE+ ports, with 1100-WAC power supply 1 RU, IP Services feature set

Switch Model	Cisco IOS Image	Description
WS-3850-24U-E	IP Services	Cisco Catalyst 3850 Stackable 24 10/100/1000 Cisco UPOE ports, 1 network module slot, 1100-W power supply
WS-3850-48U-E	IP Services	Cisco Catalyst 3850 Stackable 48 10/100/1000 Cisco UPOE ports, 1 network module slot, 1100-W power supply
WS-C3850-12S-E	IP Services	Stackable, 2 SFP module slots, 1 network module slot, 350-W power supply
WS-C3850-24S-E	IP Services	Stackable, 24 SFP module slots, 1 network module slot, 350-W power supply
WS-C3850-12XS-E	IP Services	Catalyst 3850 12-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 350 -W power supply.
WS-C3850-16XS-E	IP Services	Catalyst 3850 16-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 350 W power supply.  16 ports are available when the C3850-NM-4-10G network module is plugged into the WS-C3850-12XS-E switch.
WS-C3850-24XS-E	IP Services	Catalyst 3850 24-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 715 W power supply.
WS-C3850-32XS-E	IP Services	Catalyst 3850 32-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 715 W power supply.  32 ports are available when the C3850-NM-8-10G network module is plugged into the WS-C3850-24XS-E switch.
WS-C3850-48XS-E	IP Services	Stackable, SFP+ transceivers, 48 ports that support up to 10 G, and 4 ports that support up to 40 G. 750 W power supply.
WS-C3850-48XS-F-E	IP Services	Stackable, SFP+ transceivers, 48 ports that support up to 10 G, and 4 ports that support up to 40 G. 750 W power supply.
WS-C3850-24XU-E	IP Services	Stackable 24 100M/1G/2.5G/5G/10G UPoE ports, 1 network module slot, 1100-W power supply.

## How to Configure the COAP Proxy Server

To configure the COAP proxy server, you can configure the COAP Proxy and COAP Endpoints in the Configuration mode.

The commands are: **coap [proxy | endpoints]**.

### Configuring the COAP Proxy

To start or stop the COAP proxy on the switch, perform the steps given below:



## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>coap proxy</b> <b>Example:</b> Device (config)# <b>coap proxy</b>	Enters the COAP proxy sub mode. <b>Note</b> To stop the coap proxy and delete all configurations under coap proxy, use the <b>no coap proxy</b> command.
<b>Step 4</b>	<b>security</b> [ <b>none</b> [[ <b>ipv4</b>   <b>ipv6</b> ] { <i>ip-address ip-mask/prefix</i> }   <b>list</b> { <i>ipv4-list name</i>   <i>ipv6-list-name</i> }]   <b>dtls</b> [ <b>id-trustpoint</b> { <i>identity-trustpoint label</i> }] [ <b>verification-trustpoint</b> { <i>verification-trustpoint</i> }   [ <b>ipv4</b>   <b>ipv6</b> { <i>ip-address ip-mask/prefix</i> }]   <b>list</b> { <i>ipv4-list name</i>   <i>ipv6-list-name</i> }]] <b>Example:</b> Device (config-coap-proxy)# <b>security none</b> <b>ipv4 1.1.0.0 255.255.0.0</b>	Takes the encryption type as argument. The two security modes supported are <b>none</b> and <b>dtls</b> <ul style="list-style-type: none"> <li>• <b>none</b> - Indicates no security on that port. With <b>security none</b>, a maximum of 5 ipv4 and 5 ipv6 addresses can be associated.</li> <li>• <b>dtls</b> - The DTLS security takes RSA trustpoint and Verification trustpoint which are optional. Without Verification trustpoint it does the normal Public Key Exchange. With <b>security dtls</b>, a maximum of 5 ipv4 and 5 ipv6 addresses can be associated.</li> </ul> <b>Note</b> To delete all security configurations under coap proxy, use the <b>no security</b> command.
<b>Step 5</b>	<b>max-endpoints</b> { <i>number</i> } <b>Example:</b> Device (config-coap-proxy)# <b>max-endpoints</b> <b>10</b>	(Optional) Specifies the maximum number of endpoints that can be learnt on the switch. The default value is 10. The range is 1 to 500. <b>Note</b> To delete all max-endpoints configured under coap proxy, use the <b>no max-endpoints</b> command.

	Command or Action	Purpose
<b>Step 6</b>	<b>port-unsecure</b> {port-num} <b>Example:</b> Device (config-coap-proxy) # <b>port-unsecure</b> <b>5683</b>	(Optional) Configures a port other than the default 5683. The range is 1 to 65000. <b>Note</b> To delete all port configurations under coap proxy, use the <b>no port-unsecure</b> command.
<b>Step 7</b>	<b>port-dtls</b> {port-num} <b>Example:</b> Device (config-coap-proxy) # <b>port-dtls</b> 5864	(Optional) Configures a port other than the default 5684. <b>Note</b> To delete all dtls port configurations under coap proxy, use the <b>no port-dtls</b> command.
<b>Step 8</b>	<b>resource-directory</b> [ ipv4   ipv6 ] {ip-address} <b>Example:</b> Device (config-coap-proxy) # <b>resource-directory</b> <b>ipv4 192.168.1.1</b>	Configures a unicast upstream resource directory server to which the switch can act as a COAP client. With <b>resource-directory</b> , a maximum of 5 of ipv4 and 5 ipv6, ip addresses can be configured. <b>Note</b> To delete all resource directory configurations under coap proxy, use the <b>no resource-directory</b> command.
<b>Step 9</b>	<b>list</b> [ ipv4   ipv6 ] {list-name} <b>Example:</b> Device (config-coap-proxy) # <b>list</b> ipv4 <b>trial_list</b>	(Optional) Restricts the IP address range where the lights and their resources can be learnt. Creates a named list of ip address/masks, to be used in the <b>security</b> [ <b>none</b>   <b>dtls</b> ] command options above. With <b>list</b> , a maximum of 5 ip-lists can be configured, irrespective of ipv4 or ipv6. We can configure a max of 5 ip addresses per ip-list. <b>Note</b> To delete any ip list on the COAP proxy server, use the <b>no list</b> [ <b>ipv4</b>   <b>ipv6</b> ] {list-name} command.
<b>Step 10</b>	<b>start</b> <b>Example:</b> Device (config-coap-proxy) # <b>start</b>	Starts the COAP proxy on this switch.
<b>Step 11</b>	<b>stop</b> <b>Example:</b>	Stops the COAP proxy on this switch.

	Command or Action	Purpose
	Device (config-coap-proxy) # <b>stop</b>	
<b>Step 12</b>	<b>exit</b> <b>Example:</b> Device (config-coap-proxy) # <b>exit</b>	Exits the COAP proxy sub mode.
<b>Step 13</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.

**Related Topics**

[Information About the COAP Proxy Server](#), on page 1247

[Examples: Configuring the COAP Proxy Server](#), on page 1255

## Configuring COAP Endpoints

To configure the COAP Proxy to support multiple IPv4/IPv6 static-endpoints, perform the steps given below:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>coap endpoint [ ipv4   ipv6 ] {ip-address}</b> <b>Example:</b> Device (config) # <b>coap endpoint ipv4 1.1.1.1</b> Device (config) # <b>coap endpoint ipv6 2001::1</b>	Configures the static endpoints on the switch. <ul style="list-style-type: none"> <li>• <b>ipv4</b> - Configures the IPv4 Static endpoints.</li> <li>• <b>ipv6</b> - Configures the IPv6 Static endpoints.</li> </ul>

	Command or Action	Purpose
		<b>Note</b> To stop the coap proxy on any endpoint, use the <b>no coap endpoint [ ipv4  ipv6 ] {ip-address}</b> command.
<b>Step 4</b>	<b>exit</b> <b>Example:</b>  Device(config-coap-endpoint)# <b>exit</b>	Exits the COAP endpoint sub mode.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Monitoring COAP Proxy Server

To display the COAP protocol details, use the commands in the following table:

*Table 85: Commands to Display to COAP specific data*

<b>show coap version</b>	Shows the IOS COAP version and the RFC information.
<b>show coap resources</b>	Shows the resources of the switch and those learnt by it.
<b>show coap endpoints</b>	Shows the endpoints which are discovered and learnt.
<b>show coap globals</b>	Shows the timer values and end point values.
<b>show coap stats</b>	Shows the message counts for endpoints, requests and external queries.
<b>show coap dtls-endpoints</b>	Shows the dtls endpoint status.

*Table 86: Commands to Clear COAP Commands*

<b>clear coap database</b>	Clears the COAP learnt on the switch, and the internal database of endpoint information.
----------------------------	--

To debug the COAP protocol, use the commands in the following table:

*Table 87: Commands to Debug COAP protocol*

<b>debug coap database</b>	Debugs the COAP database output.
----------------------------	----------------------------------

<b>debug coap errors</b>	Debugs the COAP errors output.
<b>debug coap events</b>	Debugs the COAP events output.
<b>debug coap packets</b>	Debugs the COAP packets output.
<b>debug coap trace</b>	Debugs the COAP traces output.
<b>debug coap warnings</b>	Debugs the COAP warnings output.
<b>debug coap all</b>	Debugs all the COAP output.



**Note** If you wish to disable the debugs, prepend the command with a "no" keyword.

## Examples: Configuring the COAP Proxy Server

This example shows how you can configure the port number 5683 to support a maximum of 10 endpoints.

```
Device#coap proxy security none ipv4 2.2.2.2 255.255.255.0 port 5683 max-endpoints 10
```

This example shows how to configure COAP proxy on *ipv4 1.1.0.0 255.255.0.0* with **no** security settings.

```
Device(config-coap-proxy) # security ?
    dtls  dtls
    none  no security

Device(config-coap-proxy) #security none ?
    ipv4  IP address range on which to learn lights
    ipv6  IPv6 address range on which to learn lights
    list  IP address range on which to learn lights

Device(config-coap-proxy) #security none ipv4 ?
    A.B.C.D {/nn || A.B.C.D} IP address range on which to learn lights

Device(config-coap-proxy) #security none ipv4 1.1.0.0 255.255.0.0
```

This example shows how to configure COAP proxy on *ipv4 1.1.0.0 255.255.0.0* with **dtls id trustpoint** security settings.

```
Device(config-coap-proxy) #security dtls ?
    id-trustpoint DTLS RSA and X.509 Trustpoint Labels
    ipv4 IP address range on which to learn lights
    ipv6 IPv6 address range on which to learn lights
    list IP address range on which to learn lights

Device(config-coap-proxy) #security dtls id-trustpoint ?
    WORD Identity TrustPoint Label

Device(config-coap-proxy) #security dtls id-trustpoint RSA-TRUSTPOINT ?
    verification-trustpoint Certificate Verification Label
    <cr>
```

```
Device(config-coap-proxy)#security dtls id-trustpoint RSA-TRUSTPOINT

Device(config-coap-proxy)#security dtls ?
  id-trustpoint DTLS RSA and X.509 Trustpoint Labels
  ipv4 IP address range on which to learn lights
  ipv6 IPv6 address range on which to learn lights
  list IP address range on which to learn lights

Device(config-coap-proxy)# security dtls ipv4 1.1.0.0 255.255.0.0
```




---

**Note** For configuring **ipv4 / ipv6 / list**, the **id-trustpoint** and (optional) **verification-trustpoint**, should be pre-configured, else the system shows an error.

---

-----

This example shows how to configure a Trustpoint. This is a pre-requisite for COAP **security dtls** with **id trustpoint** configurations.

```
ip domain-name myDomain
crypto key generate rsa general-keys exportable label MyLabel modulus 2048

Device(config)#crypto pki trustpoint MY_TRUSTPOINT
Device(ca-trustpoint)#rsa keypair MyLabel 2048
Device(ca-trustpoint)#enrollment selfsigned
Device(ca-trustpoint)#exit

Device(config)#crypto pki enroll MY_TRUSTPOINT
% Include the router serial number in the subject name? [yes/no]: no
% Include an IP address in the subject name? [no]: no
Generate Self Signed Router Certificate? [yes/no]: yes
```

-----

This example shows how to configure COAP proxy on *ipv4 1.1.0.0 255.255.0.0* with **dtls verification trustpoint** (DTLS with certificates or verification trustpoints)

```
Device(config-coap-proxy)#security dtls ?
  id-trustpoint DTLS RSA and X.509 Trustpoint Labels
  ipv4 IP address range on which to learn lights
  ipv6 IPv6 address range on which to learn lights
  list IP address range on which to learn lights

Device(config-coap-proxy)#security dtls id-trustpoint ?
  WORD Identity TrustPoint Label

Device(config-coap-proxy)#security dtls id-trustpoint RSA-TRUSTPOINT ?
  verification-trustpoint Certificate Verification Label
  <cr>

Device(config-coap-proxy)#security dtls id-trustpoint RSA-TRUSTPOINT verification-trustpoint
?
  WORD Identity TrustPoint Label

Device(config-coap-proxy)#security dtls id-trustpoint RSA-TRUSTPOINT verification-trustpoint
```

```
CA-TRUSTPOINT ?
<Cr>
```

This example shows how to configure Verification Trustpoint. This is a pre-requisite for COAP **security dtls** with **verification trustpoint** configurations.

```
Device(config)#crypto pki import CA-TRUSTPOINT pkcs12 flash:hostA.p12 password cisco123
% Importing pkcs12...
Source filename [hostA.p12]?
Reading file from flash:hostA.p12
CRYPTO_PKI: Imported PKCS12 file successfully.
```

This example shows how to create a list named trial-list, to be used in the security [ none | dtls ] command options.

```
Device(config-coap-proxy)#list ipv4 trial_list
Device (config-coap-proxy-iplist)#1.1.0.0 255.255.255.0
Device (config-coap-proxy-iplist)#2.2.0.0 255.255.255.0
Device (config-coap-proxy-iplist)#3.3.0.0 255.255.255.0
Device (config-coap-proxy-iplist)#exit
Device (config-coap-proxy)#security none list trial_list
```

This example shows all the negation commands available in the coap-proxy sub mode.

```
Device(config-coap-proxy)#no ?
  ip-list           Configure IP-List
  max-endpoints     maximum number of endpoints supported
  port-unsecure     Specify a port number to use
  port-dtls         Specify a dtls-port number to use
  resource-discovery Resource Discovery Server
  security          CoAP Security features
```

This example shows how you can configure multiple IPv4/IPv6 static-endpoints on the coap proxy.

```
Device (config)# coap endpoint ipv4 1.1.1.1
Device (config)# coap endpoint ipv4 2.1.1.1
Device (config)# coap endpoint ipv6 2001::1
```

This example shows how you can display the COAP protocol details.

```
Device#show coap version
CoAP version 1.0.0
RFC 7252
```

```
Device#show coap resources
Link format data =
</>
</1.1.1.6/cisco/context>
</1.1.1.6/cisco/actuator>
</1.1.1.6/cisco/sensor>
</1.1.1.6/cisco/lldp>
```

```

</1.1.1.5/cisco/context>
</1.1.1.5/cisco/actuator>
</1.1.1.5/cisco/sensor>
</1.1.1.5/cisco/lldp>
</cisco/flood>
</cisco/context>
</cisco/showtech>
</cisco/lldp>

```

```

-----
Device#show coap globals
Coap System Timer Values :
  Discovery   : 120 sec
  Cache Exp  : 5 sec
  Keep Alive  : 120 sec
  Client DB   : 60 sec
  Query Queue: 500 ms
  Ack delay   : 500 ms
  Timeout     : 5 sec

```

```

Max Endpoints      : 10
Resource Disc Mode : POST

```

```

-----
Device#show coap stats
Coap Stats :
Endpoints : 2
Requests  : 20
Ext Queries : 0

```

```

-----
Device#show coap endpoints
List of all endpoints :

```

```

Code : D - Discovered , N - New
#   Status  Age(s)  LastWKC(s)  IP

```

```

-----
1   D       10      94          1.1.1.6
2   D        6      34          1.1.1.5

```

```

Endpoints - Total : 2 Discovered : 2 New : 0

```

```

-----
Device#show coap dtls-endpoints

```

```

#   Index State  String State  Value  Port IP
-----
1   3     SSLOK      3          48969 20.1.1.30
2   2     SSLOK      3          53430 20.1.1.31
3   4     SSLOK      3          54133 20.1.1.32
4   7     SSLOK      3          48236 20.1.1.33

```

This example shows all options available to debug the COAP protocol.

```

Device#debug coap ?
all          Debug CoAP all
database     Debug CoAP Database
errors       Debug CoAP errors
events       Debug CoAP events
packet       Debug CoAP packet

```



```
trace      Debug CoAP Trace
warnings  Debug CoAP warnings
```

**Related Topics**

[Configuring the COAP Proxy](#), on page 1250

[Information About the COAP Proxy Server](#), on page 1247





## CHAPTER 79

# Configuring Auto SmartPorts

- [Finding Feature Information, on page 1261](#)
- [Information about Auto SmartPorts, on page 1261](#)
- [Auto SmartPort Macros, on page 1262](#)
- [Commands executed by CISCO\\_LIGHT\\_AUTO\\_SMARTPORT , on page 1262](#)
- [Enabling Auto SmartPort, on page 1263](#)
- [Configuring Mapping Between Event Triggers and Built-in Macros, on page 1264](#)
- [Example: Enabling Auto SmartPorts, on page 1265](#)
- [Example: Configuring Mapping Between Event Triggers and Built-in Macros, on page 1266](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information about Auto SmartPorts

Auto SmartPort macros dynamically configure ports based on the device type detected on the port. When the switch detects a new device on a port, it applies the appropriate Auto SmartPorts macro. When a link-down event occurs on the port, the switch removes the macro. For example, when you connect a Cisco IP phone to a port, Auto SmartPorts automatically applies the Cisco IP phone macro. The Cisco IP phone macro enables quality of service (QoS), security features, and a dedicated voice VLAN to ensure proper treatment of delay-sensitive voice traffic.

Auto SmartPorts uses event triggers to map devices to macros. The most common event triggers are based on Cisco Discovery Protocol (CDP) messages received from connected devices. The detection of a device (Cisco IP phone, Cisco wireless access point, or Cisco router) invokes an event trigger for that device.



**Note** Although Auto SmartPort detects the Cisco switch it does not invoke the event trigger automatically. The event trigger needs to be manually invoked to map the switch to macros.

Link Layer Discovery Protocol (LLDP) is used to detect devices that do not support CDP. Other mechanisms used as event triggers include the 802.1X authentication result and MAC-address learned.

System built-in event triggers exist for various devices based mostly on CDP and LLDP messages and some MAC address. These triggers are enabled as long as Auto SmartPort is enabled.

You can configure user-defined trigger groups for profiles and devices. The name of the trigger group is used to associate a user-defined macro.

## Auto SmartPort Macros

The Auto SmartPort macros are groups of CLI commands. Detection of devices on a port triggers the application of the macro for the device. System built-in macros exist for various devices, and, by default, system built-in triggers are mapped to the corresponding built-in macros. You can change the mapping of built-in triggers or macros as needed.

A macro basically applies or removes a set of CLIs on an interface based on the link status. In a macro, the link status is checked. If the link is up, then a set of CLIs is applied; if the link is down, the set is removed (the no format of the CLIs are applied). The part of the macro that applies the set of CLIs is termed macro. The part that removes the CLIs (the no format of the CLIs) are termed antimacro.

When a device is connected to an Auto SmartPort, if it gets classified as a lighting end point, it invokes the event trigger `CISCO_LIGHT_EVENT`, and the macro `CISCO_LIGHT_AUTO_SMARTPORT` is executed.

### Related Topics

[Enabling Auto SmartPort](#), on page 1263

[Example: Enabling Auto SmartPorts](#), on page 1265

## Commands executed by CISCO\_LIGHT\_AUTO\_SMARTPORT

When the macro is executed, it runs a series of commands on the switch.

The commands that are executed by running the macro `CISCO_LIGHT_AUTO_SMARTPORT` are:

- `switchport mode access`
- `switchport port-security violation restrict`
- `switchport port-security mac-address sticky`
- `switchport port-security`
- `power inline port poe-ha`
- `storm-control broadcast level 50.00`
- `storm-control multicast level 50.00`
- `storm-control unicast level 50.00`

- spanning-tree portfast
- spanning-tree bpduguard enable

## Enabling Auto SmartPort



**Note** Auto SmartPort is disabled by default.

To disable Auto SmartPorts macros on a specific port, use the **no macro auto global processing** interface command before enabling Auto SmartPort globally.

To enable Auto SmartPort globally, use the **macro auto global processing** global configuration command.

To enable Auto SmartPorts, perform this task:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>device classifier</b> <b>Example:</b> Device(config)# <b>device classifier</b>	Enables the device classifier. Use <b>no device classifier</b> command to disable the device classifier.
<b>Step 4</b>	<b>macro auto global processing</b> <b>Example:</b> Device(config)# <b>macro auto global processing</b>	Enables Auto SmartPorts on the switch globally. Use <b>no macro auto global processing</b> command to disable Auto SmartPort globally.
<b>Step 5</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	Device(config)# <b>end</b>	
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Auto SmartPort Macros](#), on page 1262

[Example: Enabling Auto SmartPorts](#), on page 1265

## Configuring Mapping Between Event Triggers and Built-in Macros



**Note** You need to perform this task when a Cisco switch is connected to the Auto SmartPort.

To map an event trigger to a built-in macros, perform this task:

**Before you begin**

You need to enable auto smartport macros globally.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Switch> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Switch# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>macro auto execute</b> <i>event trigger</i> <b>builtin</b> <i>built-in macro name</i> <b>Example:</b> <pre>Switch(config)# macro auto execute CISCO_SWITCH_EVENT builtin CISCO_SWITCH_AUTO_SMARTPORT</pre>	Specifies a user-defined event trigger and a macro name. This action configures mapping from an event trigger to a built-in Auto Smartports macro.
<b>Step 4</b>	<b>macro auto trigger</b> <i>event trigger</i> <b>Example:</b> <pre>Switch(config)# macro auto trigger CISCO_SWITCH_EVENT</pre>	Invokes the user-defined event trigger.
<b>Step 5</b>	<b>device</b> <i>device_ID</i> <b>Example:</b> <pre>Switch(config)# device cisco WS-C3560CX-8PT-S</pre>	Matches the event trigger to the device identifier.
<b>Step 6</b>	<b>end</b> <b>Example:</b> <pre>Switch(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show shell triggers</b> <b>Example:</b> <pre>Switch# show shell triggers</pre>	Displays the event triggers on the switch.
<b>Step 8</b>	<b>show running-config</b> <b>Example:</b> <pre>Switch# show running-config</pre>	Verifies your entries.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Switch# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Example: Enabling Auto SmartPorts

This example shows how you can enable to Auto SmartPort.

```
Device> enable
Device# configure terminal
Device(config)# device classifier
Device(config)# macro auto global processing
Device(config)# end
```

### Related Topics

[Enabling Auto SmartPort](#), on page 1263

[Auto SmartPort Macros](#), on page 1262

## Example: Configuring Mapping Between Event Triggers and Built-in Macros

This example shows how you can configure mapping between event triggers and built-in macros.

```
Switch> enable
Switch# configure terminal
Switch(config)# macro auto execute CISCO_SWITCH_EVENT builtin CISCO_SWITCH_AUTO_SMARTPORT
Switch(config)# macro auto trigger CISCO_SWITCH_EVENT
Switch(config)# device cisco WS-C3560CX-8PT-S
Switch(config)# end
```





## CHAPTER 80

# Configuring 2-event Classification

- [Finding Feature Information, on page 1267](#)
- [Information about 2-event Classification, on page 1267](#)
- [Configuring 2-event Classification, on page 1267](#)
- [Example: Configuring 2-Event Classification, on page 1268](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information about 2-event Classification

When a class 4 device gets detected, IOS allocates 30W without any CDP or LLDP negotiation. This means that even before the link comes up the class 4 power device gets 30W.

Also, on the hardware level the PSE does a 2-event classification which allows a class 4 PD to detect PSE capability of providing 30W from hardware, register itself and it can move up to PoE+ level without waiting for any CDP/LLDP packet exchange.

Once 2-event is enabled on a port, you need to manually shut/un-shut the port or connect the PD again to start the IEEE detection again. Power budget allocation for a class-4 device will be 30W if 2-event classification is enabled on the port, else it will be 15.4W.

## Configuring 2-event Classification

To configure the switch for a 2-event Classification, perform the steps given below:

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet2/0/1</b>	Specifies the physical port to be configured, and enters interface configuration mode.
<b>Step 4</b>	<b>power inline port 2-event</b> <b>Example:</b> Device(config-if)# <b>power inline port 2-event</b>	Configures 2-event classification on the switch.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

**Related Topics**

[Example: Configuring 2-Event Classification](#), on page 1268

## Example: Configuring 2-Event Classification

This example shows how you can configure 2-event classification.

```
Device> enable
Device# configure terminal
Device(config)# interface gigabitethernet2/0/1
Device(config-if)# power inline port 2-event
Device(config-if)# end
```

**Related Topics**

[Configuring 2-event Classification](#), on page 1267



# CHAPTER 81

## Configuring Perpetual and Fast POE

- [Restrictions for Perpetual and Fast PoE, on page 1269](#)
- [Perpetual POE, on page 1269](#)
- [Fast POE, on page 1269](#)
- [Supported Hardware for Perpetual POE and Fast POE, on page 1270](#)
- [Configuring Perpetual and Fast POE, on page 1272](#)
- [Example: Configuring Perpetual and Fast POE, on page 1273](#)

### Restrictions for Perpetual and Fast PoE

The following restrictions apply to perpetual and fast PoE :

- When the switches are power-stacked, perpetual and fast PoE functionalities may not work as expected. This is due to power budget shortage.
- The CREE light PD may flap at regular intervals if not configured with IP assigned from the DHCP server.
- If the PD doesn't support LLDP user can configure with either static or 2-event to receive required power as per the PD specification.

### Perpetual POE

The Perpetual POE provides uninterrupted power to connected PD device even when the PSE switch is booting.



**Note**

Power to the ports will be interrupted in case of MCU firmware upgrade and ports will be back up immediately after the upgrade.

### Fast POE

This feature remembers the last power drawn from a particular PSE port and switches on power the moment AC power is plugged in (within 15 to 20 seconds of switching on power) without waiting for IOS to boot up.

When **poe-ha** is enabled on a particular port, the switch on a recovery after power failure, provides power to the connected endpoint devices within short duration before even the IOS forwarding starts up.



**Note** Fast POE is supported on Catalyst 3850 only.



**Note** In case of UPOE, even though Fast POE is available on the switch side, the PD endpoints may not be able to take advantage of the same, due to the reliance on LLDP to signal the UPOE power availability. This reliance on LLDP requires that the PD endpoint still needs to wait till the IOS comes up and LLDP packet exchanges can happen, signaling the availability of UPOE power.

## Supported Hardware for Perpetual POE and Fast POE

Perpetual POE is supported on the following Catalyst 3850 Switch Models:

Switch Model	Cisco IOS Image	Description
WS-C3850-24T-S	IP Base	Cisco Catalyst 3850 Stackable 24 10/100/1000 Ethernet ports, with 350-WAC power supply 1 RU, IP Base feature set
WS-C3850-48T-S	IP Base	Cisco Catalyst 3850 Stackable 48 10/100/1000 Ethernet ports, with 350-WAC power supply 1 RU, IP Base feature set
WS-C3850-24P-S	IP Base	Cisco Catalyst 3850 Stackable 24 10/100/1000 Ethernet PoE+ ports, with 715-WAC power supply 1 RU, IP Base feature set
WS-C3850-48P-S	IP Base	Cisco Catalyst 3850 Stackable 48 10/100/1000 Ethernet PoE+ ports, with 715-WAC power supply 1 RU, IP Base feature set
WS-C3850-48F-S	IP Base	Cisco Catalyst 3850 Stackable 48 10/100/1000 Ethernet PoE+ ports, with 1100-WAC power supply 1 RU, IP Base feature set
WS-C3850-24U-S	IP Base	Stackable 24 10/100/1000 Cisco UPOE ports, 1 network module slot, 1100 W power supply
WS-C3850-48U-S	IP Base	Stackable 48 10/100/1000 Cisco UPOE ports, 1 network module slot, 1100 W power supply
WS-C3850-12S-S	IP Base	Stackable 12 SFP module slots, 1 network module slot, 350-W power supply
WS-C3850-24S-S	IP Base	Stackable 24 SFP module slots, 1 network module slot, 350-W power supply
WS-C3850-12XS-S	IP Base	Catalyst 3850 12-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 350 W power supply

Switch Model	Cisco IOS Image	Description
WS-C3850-16XS-S	IP Base	Catalyst 3850 16-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 350 W power supply.  16 ports are available when the C3850-NM-4-10G network module is plugged into the WS-C3850-12XS-S switch.
WS-C3850-24XS-S	IP Base	Catalyst 3850 24-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 715 W power supply.
WS-C3850-32XS-S	IP Base	Catalyst 3850 32-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 715 W power supply.  32 ports are available when the C3850-NM-8-10G network module is plugged into the WS-C3850-24XS-S switch.
WS-C3850-48XS-S	IP Base	Stackable, with SFP+ transceivers, 48 ports that support up to 10 G, and 4 ports that support up to 40 G. 750 W power supply.
WSC3850-48XS-F-S	IP Base	Stackable, with SFP+ transceivers, 48 ports that support up to 10 G, and 4 ports that support up to 40 G. 750 W power supply.
WS-C3850-24XU-S	IP Base	Stackable 24 100M/1G/2.5G/5G/10G UPoE ports, 1 network module slot, 1100-W power supply.
WS-C3850-24T-E	IP Services	Cisco Catalyst 3850 Stackable 24 10/100/1000 Ethernet ports, with 350-WAC power supply 1 RU, IP Services feature set
WS-C3850-48T-E	IP Services	Cisco Catalyst 3850 Stackable 48 10/100/1000 Ethernet ports, with 350-WAC power supply 1 RU, IP Services feature set
WS-C3850-24P-E	IP Services	Cisco Catalyst 3850 Stackable 24 10/100/1000 Ethernet PoE+ ports, with 715-WAC power supply 1 RU, IP Services feature set
WS-C3850-48P-E	IP Services	Cisco Catalyst 3850 Stackable 48 10/100/1000 Ethernet PoE+ ports, with 715-WAC power supply 1 RU, IP Services feature set
WS-C3850-48F-E	IP Services	Cisco Catalyst 3850 Stackable 48 10/100/1000 Ethernet PoE+ ports, with 1100-WAC power supply 1 RU, IP Services feature set
WS-3850-24U-E	IP Services	Cisco Catalyst 3850 Stackable 24 10/100/1000 Cisco UPOE ports, 1 network module slot, 1100-W power supply
WS-3850-48U-E	IP Services	Cisco Catalyst 3850 Stackable 48 10/100/1000 Cisco UPOE ports, 1 network module slot, 1100-W power supply
WS-C3850-12S-E	IP Services	Stackable, 2 SFP module slots, 1 network module slot, 350-W power supply
WS-C3850-24S-E	IP Services	Stackable, 24 SFP module slots, 1 network module slot, 350-W power supply

Switch Model	Cisco IOS Image	Description
WS-C3850-12XS-E	IP Services	Catalyst 3850 12-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 350 -W power supply.
WS-C3850-16XS-E	IP Services	Catalyst 3850 16-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 350 W power supply.  16 ports are available when the C3850-NM-4-10G network module is plugged into the WS-C3850-12XS-E switch.
WS-C3850-24XS-E	IP Services	Catalyst 3850 24-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 715 W power supply.
WS-C3850-32XS-E	IP Services	Catalyst 3850 32-port SFP+ transceiver, 1 network module slot, support for up to 10 G SFP+, 715 W power supply.  32 ports are available when the C3850-NM-8-10G network module is plugged into the WS-C3850-24XS-E switch.
WS-C3850-48XS-E	IP Services	Stackable, SFP+ transceivers, 48 ports that support up to 10 G, and 4 ports that support up to 40 G. 750 W power supply.
WS-C3850-48XS-F-E	IP Services	Stackable, SFP+ transceivers, 48 ports that support up to 10 G, and 4 ports that support up to 40 G. 750 W power supply.
WS-C3850-24XU-E	IP Services	Stackable 24 100M/1G/2.5G/5G/10G UPoE ports, 1 network module slot, 1100-W power supply.

## Configuring Perpetual and Fast POE

To configure perpetual and fast POE, perform the following steps:



**Note** You will need to configure the **perpetual-poe-ha** command before connecting the PD, or you will need to manually shut/unshut the port after configuring **poe-ha**.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 3</b>	<code>interface interface-id</code> <b>Example:</b> Device(config)# <code>interface gigabitethernet2/0/1</code>	Specifies the physical port to be configured, and enters interface configuration mode.
<b>Step 4</b>	<code>power inline port perpetual poe-ha</code> <b>Example:</b> Device(config-if)# <code>power inline port perpetual poe-ha</code>	Configures perpetual PoE. When you configure perpetual PoE on a port connected to a PD device, the PD device remains powered on during reload.
<b>Step 5</b>	<code>power inline port poe-ha</code> <b>Example:</b> Device(config-if)# <code>power inline port poe-ha</code>	Configures Fast PoE. When you configure Fast PoE, if switch is power cycled, PD device is powered on within 10-15 seconds of plugging into a power source without waiting for IOS to boot up.  <b>Note</b> You should configure perpetual PoE using <code>power inline port perpetual-poe-ha</code> command before configuring Fast PoE using <code>power inline port poe-ha</code> command.
<b>Step 6</b>	<code>end</code> <b>Example:</b> Device(config-if)# <code>end</code>	Returns to privileged EXEC mode.

## Example: Configuring Perpetual and Fast POE

This example shows how you can configure perpetual PoE on the switch.

```
Device> enable
Device# configure terminal
Device(config)# interface gigabitethernet2/0/1
Device(config-if)# power inline port perpetual poe-ha
Device(config-if)# end
```

This example shows how you can configure fast PoE on the switch.

```
Device> enable
Device# configure terminal
Device(config)# interface gigabitethernet2/0/1
Device(config-if)# power inline port perpetual poe-ha
Device(config-if)# power inline port poe-ha
Device(config-if)# end
```

This example shows what happens if you configure fast PoE before configuring perpetual PoE.

```
Device> enable
Device# configure terminal
Device(config)# interface gigabitethernet2/0/1
Device(config-if)# power inline port poe-ha
Interface Gi2/0/1:INFO: Please execute "power inline port perpetual-poe-ha"
configuration command when "power inline port poe-ha" is configured on
the interface to enable fast poe
Device(config-if)# power inline port perpetual poe-ha
Device(config-if)# end
```

This example shows what happens when you disable perpetual PoE without disabling fast PoE on the interface.

```
Device> enable
Device# configure terminal
Device(config)# interface gigabitethernet2/0/1
Device(config-if)# power inline port poe-ha
Interface Gi2/0/1:INFO: Please execute "power inline port perpetual-poe-ha"
configuration command when "power inline port poe-ha" is configured on
the interface to enable fast poe
Device(config-if)# power inline port perpetual poe-ha
Device(config-if)# no power inline port poe-ha
Device(config-if)# power inline port poe-ha
Device(config-if)# no power inline port perpetual poe-ha
Interface Gi2/0/1:INFO: Please execute "no power inline port poe-ha"
configuration command, as fast poe has no effect without "power inline
port perpetual-poe-ha" configuration on the interface
Device(config-if)# end
```





## CHAPTER 82

# Frequently Asked Questions

---

- [Finding Feature Information, on page 1275](#)
- [Frequently Asked Questions, on page 1275](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Frequently Asked Questions

This section lists some frequently asked questions about Network Powered Lighting.

- **Question:**

What does "New Endpoint" in the "show coap stats" output mean? When does "New Endpoint" migrate to "Endpoint"?

**Answer:**

New endpoint means that an endpoint has been seen (Discovery packets received) but not yet registered by the CoAP proxy. The CoAP proxy will periodically look at the new endpoint and then send them a GET on “./well-known/core” to get more details, and once RSP is received, it is moved to “Endpoint”.

- **Question:**

Why can I not do a "CoAP start" unless there is a security configuration?

**Answer:**

We need to ensure that all configurations related to CoAP are done and then it can be explicitly enabled. This avoids any intermittent unstable states across configurations.

- **Question:**

Why do we need to enforce drop into the “coap proxy” configuration mode “coap proxy <cr>”? When I have completed the configuration, I have to exit twice to get back to the switch prompt. I do not find this very user friendly.

**Answer:**

We would alternatively have to type “coap proxy” as prefix for each configuration that we do. It is a better option to get into a sub-mode, as all the configurations under the sub-mode relating to coap-proxy can be done.

• **Question:**

Why am I not able to unconfigure security or other parameters without first stopping the coap process?

**Answer:**

We need to ensure that all configurations related to CoAP are done and then it can be explicitly enabled. This also avoids and controls the complexity where the user might configure settings on the fly, when CoAP is enabled.

• **Question:**

When I stop coap, all configurations associated with the CoAP process are not removed automatically (or return to defaults). Why does the CoAP remember previous configuration? This seems very hard for users to start fresh.

**Answer:**

The system has been intentionally designed this way and this is expected behavior. Sometimes we just want to make minor changes, like change max-endpoints and re-start the proxy. It is a better option to hold all other configurations in place, else the user has to configure everything all over again.

• **Question:**

How can I see what the security configurations have been set?

**Answer:**

The command “show run” shows all the configurations.

• **Question:**

How can I tune the timer values?

```
Example:
wtsao-3850#sho coap glo
Coap System Timer Values:
Discovery : 120 sec
Cache Exp : 5 sec
Keep Alive : 120 sec
Client DB : 5 sec
Query Queue : 500 ms
Ack delay : 500 ms
Timeout : 5 sec
Max Endpoints : 500
Resource Disc Mode : POST
```

**Answer:**

The timer values are fixed and are not tunable at the moment. The reason for this is to avoid inconsistency across systems.

- **Question:**

What are the commands “list” and “endpoint” used for?

- **Answer:**

The “list” command is to make it easier to configure multiple ip-addresses and give a name to it. Then you can assign the name instead of a single ip, to represent multiple ip’s. The “endpoint” command is used to configure a static end point, in cases where the endpoints do not advertise themselves.

- **Question:**

How can I find the endpoint-to-port mapping by using the “show” command?

- **Answer:**

We do not support that of now. However, other commands can be run to fetch this data. Currently, we can still get all the details mentioned using individual commands like “lldp neighbours”, “ip dhcp”, “power inlines” and so on.





# PART **XIV**

## **Quality of Service**

- [Configuring QoS, on page 1281](#)





## CHAPTER 83

# Configuring QoS

- [Finding Feature Information, on page 1281](#)
- [Prerequisites for Auto-QoS, on page 1282](#)
- [Restrictions for Auto-QoS, on page 1282](#)
- [Information About Configuring Auto-QoS, on page 1283](#)
- [How to Configure Auto-QoS, on page 1285](#)
- [Monitoring Auto-QoS, on page 1291](#)
- [Troubleshooting Auto-QoS, on page 1291](#)
- [Configuration Examples for Auto-QoS, on page 1291](#)
- [Where to Go Next for Auto-QoS, on page 1321](#)
- [Additional References for Auto-QoS, on page 1321](#)
- [Feature History and Information for Auto-QoS, on page 1322](#)
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- [Prerequisites for Quality of Service, on page 1322](#)
- [QoS Components, on page 1323](#)
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- [How to Configure QoS, on page 1365](#)
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- [Feature History and Information for QoS, on page 1431](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Auto-QoS

The prerequisites for auto-QoS are the same as the prerequisites for standard QoS.

## Restrictions for Auto-QoS

The following are restrictions for auto-QoS:

- Auto-qos is not supported on SVI interfaces.
- Auto-QoS is not supported on an Etherchannel interface. When applied on member ports, all port-channel interfaces should share the same Auto-QoS policy.
- The **trust device *device\_type*** command available in interface configuration mode is a stand-alone command on the switch. When using this command, if the connected peer device is not a corresponding device (defined as a device matching your trust policy), both CoS and DSCP values are set to "0" and any input policy will not take effect. If the connected peer device is a corresponding device, input policy will take effect.
- When upgrading your software release from a pre- 3.2.2 software version to a 3.2.2 or later software version, you must follow the auto-QoS upgrade procedure described in this chapter.
- Do not configure the **auto qos voip cisco-phone** option for IP phones that support video. This option causes DSCP markings of video packets to get overwritten, because these packets do not have Expedited Forwarding priority, which results in these packets getting classified in the class-default class.
- Auto-QoS does not generate configuration when it is pushed from the startup-configuration using the **auto qos voip cisco-phone** command to the running-configuration. This is expected behavior and this is to prevent overwriting of user-created customized QoS policies by the default configuration, if any, every time the command **auto qos voip cisco-phone** is pushed from the startup-config.

You can use any of the following workarounds for this limitation:

- Configure the **auto qos voip cisco-phone** command manually on the switch interfaces.
- For new switches, if you push auto-QoS commands through startup-config, the command should include each of the following as part of the standard template
  1. Interface-level:
    - **trust device cisco-phone**
    - **auto qos voip cisco-phone**
    - **service-policy input** AutoQos-4.0-CiscoPhone-Input-Policy
    - **service-policy output** AutoQos-4.0-Output-Policy
  2. Global-level:
    - Class-map
    - Policy-map
    - ACL(ACE)



- If the **auto qos voip cisco-phone** command is already configured on an interface but policies are not being generated, disable the command from all the interfaces and reconfigure the command on each interface manually.

#### Related Topics

[Upgrading Auto-QoS \(CLI\)](#), on page 1288

## Information About Configuring Auto-QoS

### Auto-QoS Overview

You can use the auto-QoS feature to simplify the deployment of QoS features. Auto-QoS determines the network design and enables QoS configurations so that the switch can prioritize different traffic flows.

The switch employs the MQC model. This means that instead of using certain global configurations, auto-QoS applied to any interface on a switch configures several global class maps and policy maps.

Auto-QoS matches traffic and assigns each matched packet to qos-groups. This allows the output policy map to put specific qos-groups into specific queues, including into the priority queue.

QoS is needed in both directions, both on inbound and outbound. When inbound, the switch port needs to trust the DSCP in the packet (done by default). When outbound, the switch port needs to give voice packets "front of line" priority. If voice is delayed too long by waiting behind other packets in the outbound queue, the end host drops the packet because it arrives outside of the receive window for that packet.

### Auto-QoS Compact Overview

When you enter an auto-QoS command, the switch displays all the generated commands as if the commands were entered from the CLI. You can use the auto-QoS compact feature to hide the auto-QoS generated commands from the running configuration. This would make it easier to comprehend the running-configuration and also help to increase efficient usage of memory.

### Auto-QoS Global Configuration Templates

In general, an auto-QoS command generates a series of class maps that either match on ACLs or on DSCP and/or CoS values to differentiate traffic into application classes. An input policy is also generated, which matches the generated classes and in some cases, polices the classes to a set bandwidth. Eight egress-queue class maps are generated. The actual egress output policy assigns a queue to each one of these eight egress-queue class maps.

The auto-QoS commands only generate templates as needed. For example, the first time any new auto-QoS command is used, global configurations that define the eight queue egress service-policy are generated. From this point on, auto-QoS commands applied to other interfaces do not generate templates for egress queuing because all auto-QoS commands rely on the same eight queue models, which have already been generated from the first time a new auto-QoS command was used.

## Auto-QoS Policy and Class Maps

After entering the appropriate auto-QoS command, the following actions occur:

- Specific class maps are created.
- Specific policy maps (input and output) are created.
- Policy maps are attached to the specified interface.
- Trust level for the interface is configured.

### Related Topics

[Configuring Auto-QoS \(CLI\)](#), on page 1285

Example: `auto qos trust cos`

Example: `auto qos trust dscp`

Example: `auto qos video cts`

Example: `auto qos video ip-camera`

Example: `auto qos video media-player`

Example: `auto qos voip trust`

Example: `auto qos voip cisco-phone`

Example: `auto qos voip cisco-softphone`

`auto qos classify police`

## Effects of Auto-QoS on Running Configuration

When auto-QoS is enabled, the **auto qos** interface configuration commands and the generated global configuration are added to the running configuration.

The switch applies the auto-QoS-generated commands as if the commands were entered from the CLI. An existing user configuration can cause the application of the generated commands to fail or to be overridden by the generated commands. These actions may occur without warning. If all the generated commands are successfully applied, any user-entered configuration that was not overridden remains in the running configuration. Any user-entered configuration that was overridden can be retrieved by reloading the switch without saving the current configuration to memory. If the generated commands are not applied, the previous running configuration is restored.

## Effects of Auto-QoS Compact on Running Configuration

If auto-QoS compact is enabled:

- Only the auto-QoS commands entered from the CLI are displayed in running-config.
- The generated global and interface configurations are hidden.
- When you save the configuration, only the auto-qos commands you have entered are saved (and not the hidden configuration).
- When you reload the switch, the system detects and re-executes the saved auto-QoS commands and the AutoQoS SRND4.0 compliant config-set is generated .



**Note** Do not make changes to the auto-QoS-generated commands when auto-QoS compact is enabled, because user-modifications are overridden when the switch reloads.

When auto-qos global compact is enabled:

- **show derived-config** command can be used to view hidden AQC derived commands.
- AQC commands will not be stored to memory. They will be regenerated every time the switch is reloaded.
- When compaction is enabled, auto-qos generated commands should not be modified .
- If the interface is configured with auto-QoS and if AQC needs to be disabled, auto-qos should be disabled at interface level first.

## How to Configure Auto-QoS

### Configuring Auto-QoS (CLI)

For optimum QoS performance, configure auto-QoS on all the devices in your network.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface</b> <b>gigabitethernet 3/0/1</b>	Specifies the port that is connected to a VoIP port, video device, or the uplink port that is connected to another trusted switch or router in the network interior, and enters the interface configuration mode.
<b>Step 3</b>	Depending on your auto-QoS configuration, use one of the following commands: <ul style="list-style-type: none"> <li>• <b>auto qos voip {cisco-phone   cisco-softphone   trust}</b></li> <li>• <b>auto qos video {cts   ip-camera   media-player}</b></li> </ul>	The following commands enable auto-QoS for VoIP: <ul style="list-style-type: none"> <li>• <b>auto qos voip cisco-phone</b>—If the port is connected to a Cisco IP Phone, the QoS labels of incoming packets are only trusted (conditional trust through CDP) when the telephone is detected.</li> </ul>

	Command or Action	Purpose
	<ul style="list-style-type: none"> <li>• <b>auto qos classify</b> [<b>police</b>]</li> <li>• <b>auto qos trust</b> {<b>cos</b>   <b>dscp</b>}</li> </ul> <p><b>Example:</b></p> <pre>Device(config-if)# auto qos trust dscp</pre>	<p><b>Note</b> Do not configure the <b>auto qos voip cisco-phone</b> option for IP phones that support video. This option causes DSCP markings of video packets to get overwritten, because these packets do not have Expedited Forwarding priority, which results in these packets getting classified in the class-default class.</p> <ul style="list-style-type: none"> <li>• <b>auto qos voip cisco-softphone</b>—The port is connected to device running the Cisco SoftPhone feature. This command generates a QoS configuration for interfaces connected to PCs running the Cisco IP SoftPhone application and mark, as well as police traffic coming from such interfaces. Ports configured with this command are considered untrusted.</li> <li>• <b>auto qos voip trust</b>—The uplink port is connected to a trusted switch or router, and the VoIP traffic classification in the ingress packet is trusted.</li> </ul> <p>The following commands enable auto-QoS for the specified video device (system, camera, or media player):</p> <ul style="list-style-type: none"> <li>• <b>auto qos video cts</b>—A port connected to a Cisco Telepresence system. QoS labels of incoming packets are only trusted (conditional trust through CDP) when a Cisco TelePresence is detected.</li> <li>• <b>auto qos video ip-camera</b>—A port connected to a Cisco video surveillance camera. QoS labels of incoming packets are only trusted (conditional trust through CDP) when a Cisco camera is detected.</li> <li>• <b>auto qos video media-player</b>—A port connected to a CDP-capable Cisco digital media player. QoS labels of incoming packets are only trusted (conditional trust through CDP) when a digital media player is detected.</li> </ul>

	Command or Action	Purpose
		<p>The following command enables auto-QoS for classification:</p> <ul style="list-style-type: none"> <li>• <b>auto qos classify police</b>— This command generates a QoS configuration for untrusted interfaces. The configuration places a service-policy on the interface to classify traffic coming from untrusted desktops/devices and mark them accordingly. The service-policies generated do police.</li> </ul> <p>The following commands enable auto-QoS for trusted interfaces:</p> <ul style="list-style-type: none"> <li>• <b>auto qos trust cos</b>—Class of service.</li> <li>• <b>auto qos trust dscp</b>—Differentiated Services Code Point.</li> </ul>
<b>Step 4</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.
<b>Step 5</b>	<p><b>show auto qos interface <i>interface-id</i></b></p> <p><b>Example:</b></p> <pre>Device# show auto qos interface gigabitethernet 3/0/1</pre>	(Optional) Displays the auto-QoS command on the interface on which auto-QoS was enabled. Use the <b>show running-config</b> command to display the auto-QoS configuration and user modifications.

### Related Topics

[Auto-QoS Policy and Class Maps](#), on page 1284

Example: [auto qos trust cos](#)

Example: [auto qos trust dscp](#)

Example: [auto qos video cts](#)

Example: [auto qos video ip-camera](#)

Example: [auto qos video media-player](#)

Example: [auto qos voip trust](#)

Example: [auto qos voip cisco-phone](#)

Example: [auto qos voip cisco-softphone](#)

[auto qos classify police](#)

## Upgrading Auto-QoS (CLI)

This procedure should only be followed when upgrading your software release from a pre- 3.2.2 software version to a 3.2.2 or later software version.

### Before you begin

Prior to upgrading, you need to remove all auto-QoS configurations currently on the switch. This sample procedure describes that process.

After following this sample procedure, you must then reboot the switch with the new or upgraded software image and reconfigure auto-QoS.

### Procedure

---

#### Step 1 **show auto qos**

##### Example:

```
Device# show auto qos

GigabitEthernet2/0/3
auto qos voip cisco-phone

GigabitEthernet2/0/27
auto qos voip cisco-softphone
```

In privileged EXEC mode, record all current auto QoS configurations by entering this command.

#### Step 2 **no auto qos**

##### Example:

```
Device(config-if)#no auto qos
```

In interface configuration mode, run the appropriate **no auto qos** command on each interface that has an auto QoS configuration.

#### Step 3 **show running-config | i autoQos**

##### Example:

```
Device# show running-config | i autoQos
```

Return to privileged EXEC mode, and record any remaining auto QoS maps class maps, policy maps, access lists, table maps, or other configurations by entering this command.

#### Step 4 **no policy-map *policy-map\_name***

##### Example:

```
Device)config# no policy-map pmap_101
Device)config# no class-map cmap_101
Device)config# no ip access-list extended AutoQos-101
```

```
Device) config# no table-map 101
Device) config# no table-map policed-dscp
```

In global configuration mode, remove the QoS class maps, policy maps, access-lists, table maps, and any other auto QoS configurations by entering these commands:

- **no policy-map** *policy-map-name*
- **no class-map** *class-map-name*
- **no ip access-list extended** *Auto-QoS-x*
- **no table-map** *table-map-name*
- **no table-map policed-dscp**

**Step 5**    **show running-config | i AutoQoS**

**Example:**

```
Device# show running-config | i AutoQoS
```

Return to privileged EXEC mode, run this command again to ensure that no auto-QoS configuration or remaining parts of the auto-QoS configuration exists

**Step 6**    **show auto qos**

**Example:**

```
Device# show auto qos
```

Run this command to ensure that no auto-QoS configuration or remaining parts of the configuration exists.

**Step 7**    **write memory**

**Example:**

```
Device# write memory
```

Write the changes to the auto QoS configuration to NV memory by entering the **write memory** command.

---

**What to do next**

Reboot the switch with the new or upgraded software image.

After rebooting with the new or upgraded software image, re-configure auto-QoS for the appropriate switch interfaces as determined by running the **show auto qos** command described in step 1.



---

**Note** There is only one table-map for exceed and another table-map for violate markdown per switch or stack. If the switch already has a table-map under the exceed action, then the auto-qos policy cannot be applied.

---

**Related Topics**

[Restrictions for Auto-QoS](#), on page 1282

## Enabling Auto-Qos Compact

To enable auto-Qos compact, enter this command:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>auto qos global compact</b> <b>Example:</b> Device(config)# <code>auto qos global compact</code>	Enables auto-Qos compact and generates (hidden) the global configurations for auto-QoS. You can then enter the auto-QoS command you want to configure in the interface configuration mode and the interface commands that the system generates are also hidden.  To display the auto-QoS configuration that has been applied, use these the privileged EXEC commands: <ul style="list-style-type: none"> <li>• <b>show derived-config</b></li> <li>• <b>show policy-map</b></li> <li>• <b>show access-list</b></li> <li>• <b>show class-map</b></li> <li>• <b>show table-map</b></li> <li>• <b>show auto-qos</b></li> <li>• <b>show policy-map interface</b></li> <li>• <b>show ip access-lists</b></li> </ul> These commands will have keyword "AutoQos-".

**What to do next**

To disable auto-QoS compact, remove auto-Qos instances from all interfaces by entering the **no** form of the corresponding auto-QoS commands and then enter the **no auto qos global compact** global configuration command.



# Monitoring Auto-QoS

Table 88: Commands for Monitoring Auto-QoS

Command	Description
<code>show auto qos [interface [interface-id]]</code>	Displays the initial auto-QoS configuration. You can compare the <b>show auto qos</b> and the <b>show running-config</b> command output to identify the user-defined QoS settings.
<code>show running-config</code>	Displays information about the QoS configuration that might be affected by auto-QoS. You can compare the <b>show auto qos</b> and the <b>show running-config</b> command output to identify the user-defined QoS settings.
<code>show derived-config</code>	Displays the hidden <b>mls qos</b> command which get configured along with the running configs because of auto-qos template.

## Troubleshooting Auto-QoS

To troubleshoot auto-QoS, use the **debug auto qos** privileged EXEC command. For more information, see the **debug auto qos** command in the command reference for this release.

To disable auto-QoS on a port, use the **no** form of the **auto qos** command interface configuration command, such as **no auto qos voip**. Only the auto-QoS-generated interface configuration commands for this port are removed. If this is the last port on which auto-QoS is enabled and you enter the **no auto qos voip** command, auto-QoS is considered disabled even though the auto-QoS-generated global configuration commands remain (to avoid disrupting traffic on other ports affected by the global configuration).

## Configuration Examples for Auto-QoS

### Example: auto qos trust cos

The following is an example of the **auto qos trust cos** command and the applied policies and class maps.

The following policy maps are created and applied when running this command:

- AutoQos-4.0-Trust-Cos-Input-Policy
- AutoQos-4.0-Output-Policy

The following class maps are created and applied when running this command:

- class-default (match-any)

- AutoQos-4.0-Output-Priority-Queue (match-any)
- AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
- AutoQos-4.0-Output-Trans-Data-Queue (match-any)
- AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
- AutoQos-4.0-Output-Scavenger-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)

```

Device(config)# interface GigabitEthernet1/0/17
Device(config-if)# auto qos trust cos
Device(config-if)# end
Device# show policy-map interface GigabitEthernet1/0/17

GigabitEthernet1/0/17

Service-policy input: AutoQos-4.0-Trust-Cos-Input-Policy

Class-map: class-default (match-any)
  0 packets
  Match: any
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    cos cos table AutoQos-4.0-Trust-Cos-Table

Service-policy output: AutoQos-4.0-Output-Policy

queue stats for all priority classes:
  Queueing
  priority level 1

  (total drops) 0
  (bytes output) 0

Class-map: AutoQos-4.0-Output-Priority-Queue (match-any)
  0 packets
  Match: dscp cs4 (32) cs5 (40) ef (46)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 5
    0 packets, 0 bytes
    5 minute rate 0 bps
  Priority: 30% (300000 kbps), burst bytes 7500000,

  Priority Level: 1

Class-map: AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
  0 packets
  Match: dscp cs2 (16) cs3 (24) cs6 (48) cs7 (56)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 3
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing
  queue-limit dscp 16 percent 80

```

```
queue-limit dscp 24 percent 90
queue-limit dscp 48 percent 100
queue-limit dscp 56 percent 100

(total drops) 0
(bytes output) 0
bandwidth remaining 10%

queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
 0 packets
Match: dscp af41 (34) af42 (36) af43 (38)
 0 packets, 0 bytes
 5 minute rate 0 bps
Match: cos 4
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Trans-Data-Queue (match-any)
 0 packets
Match: dscp af21 (18) af22 (20) af23 (22)
 0 packets, 0 bytes
 5 minute rate 0 bps
Match: cos 2
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
 0 packets
Match: dscp af11 (10) af12 (12) af13 (14)
 0 packets, 0 bytes
 5 minute rate 0 bps
Match: cos 1
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 4%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Scavenger-Queue (match-any)
 0 packets
Match: dscp cs1 (8)
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
```

```

bandwidth remaining 1%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)
 0 packets
Match: dscp af31 (26) af32 (28) af33 (30)
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: class-default (match-any)
 0 packets
Match: any
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 25%
queue-buffers ratio 25

```

## Example: auto qos trust dscp

The following is an example of the **auto qos trust dscp** command and the applied policies and class maps.

The following policy maps are created and applied when running this command:

- AutoQos-4.0-Trust-Dscp-Input-Policy
- AutoQos-4.0-Output-Policy

The following class maps are created and applied when running this command:

- class-default (match-any)
- AutoQos-4.0-Output-Priority-Queue (match-any)
- AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
- AutoQos-4.0-Output-Trans-Data-Queue (match-any)
- AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
- AutoQos-4.0-Output-Scavenger-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)

```

Device(config)# interface GigabitEthernet1/0/18
Device(config-if)# auto qos trust dscp
Device(config-if)# end
Device#show policy-map interface GigabitEthernet1/0/18

```

```
GigabitEthernet1/0/18

Service-policy input: AutoQos-4.0-Trust-Dscp-Input-Policy

Class-map: class-default (match-any)
  0 packets
  Match: any
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    dscp dscp table AutoQos-4.0-Trust-Dscp-Table

Service-policy output: AutoQos-4.0-Output-Policy

queue stats for all priority classes:
  Queueing
  priority level 1

  (total drops) 0
  (bytes output) 0

Class-map: AutoQos-4.0-Output-Priority-Queue (match-any)
  0 packets
  Match: dscp cs4 (32) cs5 (40) ef (46)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 5
    0 packets, 0 bytes
    5 minute rate 0 bps
  Priority: 30% (300000 kbps), burst bytes 7500000,

  Priority Level: 1

Class-map: AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
  0 packets
  Match: dscp cs2 (16) cs3 (24) cs6 (48) cs7 (56)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 3
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing
  queue-limit dscp 16 percent 80
  queue-limit dscp 24 percent 90
  queue-limit dscp 48 percent 100
  queue-limit dscp 56 percent 100

  (total drops) 0
  (bytes output) 0
  bandwidth remaining 10%

  queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
  0 packets
  Match: dscp af41 (34) af42 (36) af43 (38)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 4
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing
```

```

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Trans-Data-Queue (match-any)
 0 packets
Match: dscp af21 (18) af22 (20) af23 (22)
 0 packets, 0 bytes
 5 minute rate 0 bps
Match: cos 2
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
 0 packets
Match: dscp af11 (10) af12 (12) af13 (14)
 0 packets, 0 bytes
 5 minute rate 0 bps
Match: cos 1
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 4%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Scavenger-Queue (match-any)
 0 packets
Match: dscp cs1 (8)
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 1%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)
 0 packets
Match: dscp af31 (26) af32 (28) af33 (30)
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: class-default (match-any)
 0 packets
Match: any
 0 packets, 0 bytes

```

```

    5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 25%
queue-buffers ratio 25

```

## Example: auto qos video cts

The following is an example of the **auto qos video cts** command and the applied policies and class maps.

The following policy maps are created and applied when running this command:

- AutoQos-4.0-Trust-Cos-Input-Policy
- AutoQos-4.0-Output-Policy

The following class maps are created and applied when running this command:

- class-default (match-any)
- AutoQos-4.0-Output-Priority-Queue (match-any)
- AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
- AutoQos-4.0-Output-Trans-Data-Queue (match-any)
- AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
- AutoQos-4.0-Output-Scavenger-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)

```

Device(config)# interface GigabitEthernet1/0/12
Device(config-if)# auto qos video cts
Device(config-if)# end
Device# show policy-map interface GigabitEthernet1/0/12

GigabitEthernet1/0/12

Service-policy input: AutoQos-4.0-Trust-Cos-Input-Policy

Class-map: class-default (match-any)
  0 packets
  Match: any
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    cos cos table AutoQos-4.0-Trust-Cos-Table

Service-policy output: AutoQos-4.0-Output-Policy

queue stats for all priority classes:
  Queueing
  priority level 1

```

```

(total drops) 0
(bytes output) 0

Class-map: AutoQos-4.0-Output-Priority-Queue (match-any)
 0 packets
Match: dscp cs4 (32) cs5 (40) ef (46)
 0 packets, 0 bytes
 5 minute rate 0 bps
Match: cos 5
 0 packets, 0 bytes
 5 minute rate 0 bps
Priority: 30% (300000 kbps), burst bytes 7500000,

Priority Level: 1

Class-map: AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
 0 packets
Match: dscp cs2 (16) cs3 (24) cs6 (48) cs7 (56)
 0 packets, 0 bytes
 5 minute rate 0 bps
Match: cos 3
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing
queue-limit dscp 16 percent 80
queue-limit dscp 24 percent 90
queue-limit dscp 48 percent 100
queue-limit dscp 56 percent 100

(total drops) 0
(bytes output) 0
bandwidth remaining 10%

queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
 0 packets
Match: dscp af41 (34) af42 (36) af43 (38)
 0 packets, 0 bytes
 5 minute rate 0 bps
Match: cos 4
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Trans-Data-Queue (match-any)
 0 packets
Match: dscp af21 (18) af22 (20) af23 (22)
 0 packets, 0 bytes
 5 minute rate 0 bps
Match: cos 2
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%

```



```

queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
 0 packets
Match: dscp af11 (10) af12 (12) af13 (14)
 0 packets, 0 bytes
 5 minute rate 0 bps
Match: cos 1
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 4%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Scavenger-Queue (match-any)
 0 packets
Match: dscp cs1 (8)
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 1%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)
 0 packets
Match: dscp af31 (26) af32 (28) af33 (30)
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: class-default (match-any)
 0 packets
Match: any
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 25%
queue-buffers ratio 25

```

## Example: auto qos video ip-camera

The following is an example of the **auto qos video ip-camera** command and the applied policies and class maps.

The following policy maps are created and applied when running this command:

- AutoQos-4.0-Trust-Dscp-Input-Policy

- AutoQos-4.0-Output-Policy

The following class maps are created and applied when running this command:

- class-default (match-any)
- AutoQos-4.0-Output-Priority-Queue (match-any)
- AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
- AutoQos-4.0-Output-Trans-Data-Queue (match-any)
- AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
- AutoQos-4.0-Output-Scavenger-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)

```
Device(config)# interface GigabitEthernet1/0/9
Device(config-if)# auto qos video ip-camera
Device(config-if)# end
Device# show policy-map interface GigabitEthernet1/0/9
```

```
GigabitEthernet1/0/9
```

```
Service-policy input: AutoQos-4.0-Trust-Dscp-Input-Policy
```

```
Class-map: class-default (match-any)
  0 packets
  Match: any
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    dscp dscp table AutoQos-4.0-Trust-Dscp-Table
```

```
Service-policy output: AutoQos-4.0-Output-Policy
```

```
queue stats for all priority classes:
```

```
Queueing
priority level 1
```

```
(total drops) 0
(bytes output) 0
```

```
Class-map: AutoQos-4.0-Output-Priority-Queue (match-any)
```

```
  0 packets
  Match: dscp cs4 (32) cs5 (40) ef (46)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 5
    0 packets, 0 bytes
    5 minute rate 0 bps
  Priority: 30% (300000 kbps), burst bytes 7500000,
```

```
Priority Level: 1
```

```
Class-map: AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
```

```
  0 packets
  Match: dscp cs2 (16) cs3 (24) cs6 (48) cs7 (56)
```

```
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: cos 3
    0 packets, 0 bytes
    5 minute rate 0 bps
Queueing
queue-limit dscp 16 percent 80
queue-limit dscp 24 percent 90
queue-limit dscp 48 percent 100
queue-limit dscp 56 percent 100

(total drops) 0
(bytes output) 0
bandwidth remaining 10%

queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
 0 packets
Match: dscp af41 (34) af42 (36) af43 (38)
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: cos 4
    0 packets, 0 bytes
    5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Trans-Data-Queue (match-any)
 0 packets
Match: dscp af21 (18) af22 (20) af23 (22)
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: cos 2
    0 packets, 0 bytes
    5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
 0 packets
Match: dscp af11 (10) af12 (12) af13 (14)
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: cos 1
    0 packets, 0 bytes
    5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 4%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Scavenger-Queue (match-any)
 0 packets
```

```

Match: dscp cs1 (8)
      0 packets, 0 bytes
      5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 1%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)
0 packets
Match: dscp af31 (26) af32 (28) af33 (30)
      0 packets, 0 bytes
      5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: class-default (match-any)
0 packets
Match: any
      0 packets, 0 bytes
      5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 25%
queue-buffers ratio 25

```

## Example: auto qos video media-player

The following is an example of the **auto qos video media-player** command and the applied policies and class maps.

The following policy maps are created and applied when running this command:

- AutoQos-4.0-Trust-Dscp-Input-Policy
- AutoQos-4.0-Output-Policy

The following class maps are created and applied when running this command:

- class-default (match-any)
- AutoQos-4.0-Output-Priority-Queue (match-any)
- AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
- AutoQos-4.0-Output-Trans-Data-Queue (match-any)
- AutoQos-4.0-Output-Bulk-Data-Queue (match-any)

- AutoQos-4.0-Output-Scavenger-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)

```
Device(config)# interface GigabitEthernet1/0/7
Device(config-if)# auto qos video media-player
Device(config-if)# end
Device# show policy-map interface GigabitEthernet1/0/7
```

```
GigabitEthernet1/0/7
```

```
Service-policy input: AutoQos-4.0-Trust-Dscp-Input-Policy
```

```
Class-map: class-default (match-any)
  0 packets
  Match: any
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    dscp dscp table AutoQos-4.0-Trust-Dscp-Table
```

```
Service-policy output: AutoQos-4.0-Output-Policy
```

```
queue stats for all priority classes:
```

```
Queueing
priority level 1
```

```
(total drops) 0
(bytes output) 0
```

```
Class-map: AutoQos-4.0-Output-Priority-Queue (match-any)
```

```
  0 packets
  Match: dscp cs4 (32) cs5 (40) ef (46)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 5
    0 packets, 0 bytes
    5 minute rate 0 bps
  Priority: 30% (300000 kbps), burst bytes 7500000,
```

```
Priority Level: 1
```

```
Class-map: AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
```

```
  0 packets
  Match: dscp cs2 (16) cs3 (24) cs6 (48) cs7 (56)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 3
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing
```

```
queue-limit dscp 16 percent 80
queue-limit dscp 24 percent 90
queue-limit dscp 48 percent 100
queue-limit dscp 56 percent 100
```

```
(total drops) 0
(bytes output) 0
bandwidth remaining 10%
```

```
queue-buffers ratio 10
```

```

Class-map: AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
  0 packets
  Match: dscp af41 (34) af42 (36) af43 (38)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 4
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing

  (total drops) 0
  (bytes output) 0
  bandwidth remaining 10%
  queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Trans-Data-Queue (match-any)
  0 packets
  Match: dscp af21 (18) af22 (20) af23 (22)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 2
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing

  (total drops) 0
  (bytes output) 0
  bandwidth remaining 10%
  queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
  0 packets
  Match: dscp af11 (10) af12 (12) af13 (14)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 1
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing

  (total drops) 0
  (bytes output) 0
  bandwidth remaining 4%
  queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Scavenger-Queue (match-any)
  0 packets
  Match: dscp cs1 (8)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing

  (total drops) 0
  (bytes output) 0
  bandwidth remaining 1%
  queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)
  0 packets
  Match: dscp af31 (26) af32 (28) af33 (30)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing

```

```

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: class-default (match-any)
 0 packets
Match: any
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 25%
queue-buffers ratio 25

```

## Example: auto qos voip trust

The following is an example of the **auto qos voip trust** command and the applied policies and class maps.

The following policy maps are created and applied when running this command:

- AutoQos-4.0-Trust-Cos-Input-Policy
- AutoQos-4.0-Output-Policy

The following class maps are created and applied when running this command:

- class-default (match-any)
- AutoQos-4.0-Output-Priority-Queue (match-any)
- AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
- AutoQos-4.0-Output-Trans-Data-Queue (match-any)
- AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
- AutoQos-4.0-Output-Scavenger-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)

```

Device(config)# interface GigabitEthernet1/0/31
Device(config-if)# auto qos voip trust
Device(config-if)# end
Device# show policy-map interface GigabitEthernet1/0/31

GigabitEthernet1/0/31

Service-policy input: AutoQos-4.0-Trust-Cos-Input-Policy

Class-map: class-default (match-any)
 0 packets
Match: any
 0 packets, 0 bytes
 5 minute rate 0 bps

```

```

QoS Set
  cos cos table AutoQos-4.0-Trust-Cos-Table
Service-policy output: AutoQos-4.0-Output-Policy

queue stats for all priority classes:
  Queueing
  priority level 1

  (total drops) 0
  (bytes output) 0

Class-map: AutoQos-4.0-Output-Priority-Queue (match-any)
  0 packets
  Match: dscp cs4 (32) cs5 (40) ef (46)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 5
    0 packets, 0 bytes
    5 minute rate 0 bps
  Priority: 30% (300000 kbps), burst bytes 7500000,

  Priority Level: 1

Class-map: AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
  0 packets
  Match: dscp cs2 (16) cs3 (24) cs6 (48) cs7 (56)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 3
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing
  queue-limit dscp 16 percent 80
  queue-limit dscp 24 percent 90
  queue-limit dscp 48 percent 100
  queue-limit dscp 56 percent 100

  (total drops) 0
  (bytes output) 0
  bandwidth remaining 10%

  queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
  0 packets
  Match: dscp af41 (34) af42 (36) af43 (38)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 4
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing

  (total drops) 0
  (bytes output) 0
  bandwidth remaining 10%
  queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Trans-Data-Queue (match-any)
  0 packets
  Match: dscp af21 (18) af22 (20) af23 (22)
    0 packets, 0 bytes
    5 minute rate 0 bps

```



```
Match: cos 2
  0 packets, 0 bytes
  5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
  0 packets
  Match: dscp af11 (10) af12 (12) af13 (14)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 1
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 4%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Scavenger-Queue (match-any)
  0 packets
  Match: dscp cs1 (8)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 1%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)
  0 packets
  Match: dscp af31 (26) af32 (28) af33 (30)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: class-default (match-any)
  0 packets
  Match: any
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 25%
queue-buffers ratio 25
```

## Example: auto qos voip cisco-phone

The following is an example of the **auto qos voip cisco-phone** command and the applied policies and class maps.

The following policy maps are created and applied when running this command:

- AutoQos-4.0-CiscoPhone-Input-Policy
- AutoQos-4.0-Output-Policy

The following class maps are created and applied when running this command:

- AutoQos-4.0-Voip-Data-CiscoPhone-Class (match-any)
- AutoQos-4.0-Voip-Signal-CiscoPhone-Class (match-any)
- AutoQos-4.0-Default-Class (match-any)
- class-default (match-any)
- AutoQos-4.0-Output-Priority-Queue (match-any)
- AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
- AutoQos-4.0-Output-Trans-Data-Queue (match-any)
- AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
- AutoQos-4.0-Output-Scavenger-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)

```
Device(config)# interface GigabitEthernet1/0/5
Device(config-if)# auto qos voip cisco-phone
Device(config-if)# end
Device# show policy-map interface GigabitEthernet1/0/5

GigabitEthernet1/0/5

  Service-policy input: AutoQos-4.0-CiscoPhone-Input-Policy

    Class-map: AutoQos-4.0-Voip-Data-CiscoPhone-Class (match-any)
      0 packets
      Match: cos 5
        0 packets, 0 bytes
        5 minute rate 0 bps
      QoS Set
        dscp ef
      police:
        cir 128000 bps, bc 8000 bytes
        conformed 0 bytes; actions:
          transmit
        exceeded 0 bytes; actions:
          set-dscp-transmit dscp table policed-dscp
          conformed 0000 bps, exceed 0000 bps

    Class-map: AutoQos-4.0-Voip-Signal-CiscoPhone-Class (match-any)
      0 packets
```

```

Match: cos 3
    0 packets, 0 bytes
    5 minute rate 0 bps
QoS Set
    dscp cs3
police:
    cir 32000 bps, bc 8000 bytes
    conformed 0 bytes; actions:
        transmit
    exceeded 0 bytes; actions:
        set-dscp-transmit dscp table policed-dscp
    conformed 0000 bps, exceed 0000 bps

Class-map: AutoQos-4.0-Default-Class (match-any)
    0 packets
Match: access-group name AutoQos-4.0-Acl-Default
    0 packets, 0 bytes
    5 minute rate 0 bps
QoS Set
    dscp default

Class-map: class-default (match-any)
    0 packets
Match: any
    0 packets, 0 bytes
    5 minute rate 0 bps

Service-policy output: AutoQos-4.0-Output-Policy

queue stats for all priority classes:
    Queueing
    priority level 1

    (total drops) 0
    (bytes output) 0

Class-map: AutoQos-4.0-Output-Priority-Queue (match-any)
    0 packets
Match: dscp cs4 (32) cs5 (40) ef (46)
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: cos 5
    0 packets, 0 bytes
    5 minute rate 0 bps
Priority: 30% (300000 kbps), burst bytes 7500000,

Priority Level: 1

Class-map: AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
    0 packets
Match: dscp cs2 (16) cs3 (24) cs6 (48) cs7 (56)
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: cos 3
    0 packets, 0 bytes
    5 minute rate 0 bps
Queueing
queue-limit dscp 16 percent 80
queue-limit dscp 24 percent 90
queue-limit dscp 48 percent 100
queue-limit dscp 56 percent 100

    (total drops) 0
    (bytes output) 0

```

```
bandwidth remaining 10%

queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
 0 packets
Match: dscp af41 (34) af42 (36) af43 (38)
 0 packets, 0 bytes
 5 minute rate 0 bps
Match: cos 4
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Trans-Data-Queue (match-any)
 0 packets
Match: dscp af21 (18) af22 (20) af23 (22)
 0 packets, 0 bytes
 5 minute rate 0 bps
Match: cos 2
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
 0 packets
Match: dscp af11 (10) af12 (12) af13 (14)
 0 packets, 0 bytes
 5 minute rate 0 bps
Match: cos 1
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 4%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Scavenger-Queue (match-any)
 0 packets
Match: dscp cs1 (8)
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 1%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)
 0 packets
Match: dscp af31 (26) af32 (28) af33 (30)
```

```
    0 packets, 0 bytes
    5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: class-default (match-any)
  0 packets
Match: any
  0 packets, 0 bytes
  5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 25%
queue-buffers ratio 25
```

## Example: auto qos voip cisco-softphone

The following is an example of the **auto qos voip cisco-softphone** command and the applied policies and class maps.

The following policy maps are created and applied when running this command:

- AutoQos-4.0-CiscoSoftPhone-Input-Policy
- AutoQos-4.0-Output-Policy

The following class maps are created and applied when running this command:

- AutoQos-4.0-Voip-Data-Class (match-any)
- AutoQos-4.0-Voip-Signal-Class (match-any)
- AutoQos-4.0-Multimedia-Conf-Class (match-any)
- AutoQos-4.0-Bulk-Data-Class (match-any)
- AutoQos-4.0-Transaction-Class (match-any)
- AutoQos-4.0-Scavenger-Class (match-any)
- AutoQos-4.0-Signaling-Class (match-any)
- AutoQos-4.0-Default-Class (match-any)
- class-default (match-any)
- AutoQos-4.0-Output-Priority-Queue (match-any)
- AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
- AutoQos-4.0-Output-Trans-Data-Queue (match-any)

- AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
- AutoQos-4.0-Output-Scavenger-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)

```

Device(config)# interface GigabitEthernet1/0/20
Device(config-if)# auto qos voip cisco-softphone
Device(config-if)# end
Device# show policy-map interface GigabitEthernet1/0/20

GigabitEthernet1/0/20

Service-policy input: AutoQos-4.0-CiscoSoftPhone-Input-Policy

Class-map: AutoQos-4.0-Voip-Data-Class (match-any)
  0 packets
  Match: dscp ef (46)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 5
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    dscp ef
  police:
    cir 128000 bps, bc 8000 bytes
    conformed 0 bytes; actions:
      transmit
    exceeded 0 bytes; actions:
      set-dscp-transmit dscp table policed-dscp
    conformed 0000 bps, exceed 0000 bps

Class-map: AutoQos-4.0-Voip-Signal-Class (match-any)
  0 packets
  Match: dscp cs3 (24)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 3
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    dscp cs3
  police:
    cir 32000 bps, bc 8000 bytes
    conformed 0 bytes; actions:
      transmit
    exceeded 0 bytes; actions:
      set-dscp-transmit dscp table policed-dscp
    conformed 0000 bps, exceed 0000 bps

Class-map: AutoQos-4.0-Multimedia-Conf-Class (match-any)
  0 packets
  Match: access-group name AutoQos-4.0-Acl-MultiEnhanced-Conf
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    dscp af41
  police:
    cir 5000000 bps, bc 156250 bytes
    conformed 0 bytes; actions:
      transmit

```

```
exceeded 0 bytes; actions:
  drop
conformed 0000 bps, exceed 0000 bps

Class-map: AutoQos-4.0-Bulk-Data-Class (match-any)
  0 packets
Match: access-group name AutoQos-4.0-Acl-Bulk-Data
  0 packets, 0 bytes
  5 minute rate 0 bps
QoS Set
  dscp af11
police:
  cir 10000000 bps, bc 312500 bytes
  conformed 0 bytes; actions:
    transmit
  exceeded 0 bytes; actions:
    set-dscp-transmit dscp table policed-dscp
  conformed 0000 bps, exceed 0000 bps

Class-map: AutoQos-4.0-Transaction-Class (match-any)
  0 packets
Match: access-group name AutoQos-4.0-Acl-Transactional-Data
  0 packets, 0 bytes
  5 minute rate 0 bps
QoS Set
  dscp af21
police:
  cir 10000000 bps, bc 312500 bytes
  conformed 0 bytes; actions:
    transmit
  exceeded 0 bytes; actions:
    set-dscp-transmit dscp table policed-dscp
  conformed 0000 bps, exceed 0000 bps

Class-map: AutoQos-4.0-Scavenger-Class (match-any)
  0 packets
Match: access-group name AutoQos-4.0-Acl-Scavenger
  0 packets, 0 bytes
  5 minute rate 0 bps
QoS Set
  dscp cs1
police:
  cir 10000000 bps, bc 312500 bytes
  conformed 0 bytes; actions:
    transmit
  exceeded 0 bytes; actions:
    drop
  conformed 0000 bps, exceed 0000 bps

Class-map: AutoQos-4.0-Signaling-Class (match-any)
  0 packets
Match: access-group name AutoQos-4.0-Acl-Signaling
  0 packets, 0 bytes
  5 minute rate 0 bps
QoS Set
  dscp cs3
police:
  cir 32000 bps, bc 8000 bytes
  conformed 0 bytes; actions:
    transmit
  exceeded 0 bytes; actions:
    drop
  conformed 0000 bps, exceed 0000 bps
```

```

Class-map: AutoQos-4.0-Default-Class (match-any)
  0 packets
  Match: access-group name AutoQos-4.0-Acl-Default
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    dscp default
  police:
    cir 10000000 bps, bc 312500 bytes
    conformed 0 bytes; actions:
      transmit
    exceeded 0 bytes; actions:
      set-dscp-transmit dscp table policed-dscp
    conformed 0000 bps, exceed 0000 bps

```

```

Class-map: class-default (match-any)
  0 packets
  Match: any
    0 packets, 0 bytes
    5 minute rate 0 bps

```

Service-policy output: AutoQos-4.0-Output-Policy

```

queue stats for all priority classes:
  Queueing
  priority level 1

  (total drops) 0
  (bytes output) 0

```

```

Class-map: AutoQos-4.0-Output-Priority-Queue (match-any)
  0 packets
  Match: dscp cs4 (32) cs5 (40) ef (46)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 5
    0 packets, 0 bytes
    5 minute rate 0 bps
  Priority: 30% (300000 kbps), burst bytes 7500000,

  Priority Level: 1

```

```

Class-map: AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
  0 packets
  Match: dscp cs2 (16) cs3 (24) cs6 (48) cs7 (56)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 3
    0 packets, 0 bytes
    5 minute rate 0 bps
  Queueing
  queue-limit dscp 16 percent 80
  queue-limit dscp 24 percent 90
  queue-limit dscp 48 percent 100
  queue-limit dscp 56 percent 100

  (total drops) 0
  (bytes output) 0
  bandwidth remaining 10%

  queue-buffers ratio 10

```

```

Class-map: AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
  0 packets

```



```
Match: dscp af41 (34) af42 (36) af43 (38)
      0 packets, 0 bytes
      5 minute rate 0 bps
Match: cos 4
      0 packets, 0 bytes
      5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Trans-Data-Queue (match-any)
  0 packets
Match: dscp af21 (18) af22 (20) af23 (22)
      0 packets, 0 bytes
      5 minute rate 0 bps
Match: cos 2
      0 packets, 0 bytes
      5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
  0 packets
Match: dscp af11 (10) af12 (12) af13 (14)
      0 packets, 0 bytes
      5 minute rate 0 bps
Match: cos 1
      0 packets, 0 bytes
      5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 4%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Scavenger-Queue (match-any)
  0 packets
Match: dscp cs1 (8)
      0 packets, 0 bytes
      5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 1%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)
  0 packets
Match: dscp af31 (26) af32 (28) af33 (30)
      0 packets, 0 bytes
      5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
```

```

bandwidth remaining 10%
queue-buffers ratio 10

Class-map: class-default (match-any)
 0 packets
Match: any
 0 packets, 0 bytes
 5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 25%
queue-buffers ratio 25

```

## auto qos classify police

The following is an example of the **auto qos classify police** command and the applied policies and class maps.

The following policy maps are created and applied when running this command:

- AutoQos-4.0-Classify-Police-Input-Policy
- AutoQos-4.0-Output-Policy

The following class maps are created and applied when running this command:

- AutoQos-4.0-Multimedia-Conf-Class (match-any)
- AutoQos-4.0-Bulk-Data-Class (match-any)
- AutoQos-4.0-Transaction-Class (match-any)
- AutoQos-4.0-Scavenger-Class (match-any)
- AutoQos-4.0-Signaling-Class (match-any)
- AutoQos-4.0-Default-Class (match-any)
- class-default (match-any)
- AutoQos-4.0-Output-Priority-Queue (match-any)
- AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
- AutoQos-4.0-Output-Trans-Data-Queue (match-any)
- AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
- AutoQos-4.0-Output-Scavenger-Queue (match-any)
- AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)

```

Device(config)# interface GigabitEthernet1/0/6
Device(config-if)# auto qos classify police
Device(config-if)# end

```

```
Device# show policy-map interface GigabitEthernet1/0/6
```

```
GigabitEthernet1/0/6
```

```
Service-policy input: AutoQos-4.0-Classify-Police-Input-Policy
```

```
Class-map: AutoQos-4.0-Multimedia-Conf-Class (match-any)
  0 packets
  Match: access-group name AutoQos-4.0-Acl-MultiEnhanced-Conf
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    dscp af41
  police:
    cir 5000000 bps, bc 156250 bytes
    conformed 0 bytes; actions:
      transmit
    exceeded 0 bytes; actions:
      drop
    conformed 0000 bps, exceed 0000 bps
```

```
Class-map: AutoQos-4.0-Bulk-Data-Class (match-any)
  0 packets
  Match: access-group name AutoQos-4.0-Acl-Bulk-Data
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    dscp af11
  police:
    cir 10000000 bps, bc 312500 bytes
    conformed 0 bytes; actions:
      transmit
    exceeded 0 bytes; actions:
      set-dscp-transmit dscp table policed-dscp
    conformed 0000 bps, exceed 0000 bps
```

```
Class-map: AutoQos-4.0-Transaction-Class (match-any)
  0 packets
  Match: access-group name AutoQos-4.0-Acl-Transactional-Data
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    dscp af21
  police:
    cir 10000000 bps, bc 312500 bytes
    conformed 0 bytes; actions:
      transmit
    exceeded 0 bytes; actions:
      set-dscp-transmit dscp table policed-dscp
    conformed 0000 bps, exceed 0000 bps
```

```
Class-map: AutoQos-4.0-Scavenger-Class (match-any)
  0 packets
  Match: access-group name AutoQos-4.0-Acl-Scavenger
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    dscp cs1
  police:
    cir 10000000 bps, bc 312500 bytes
    conformed 0 bytes; actions:
      transmit
    exceeded 0 bytes; actions:
```

```

        drop
        conformed 0000 bps, exceed 0000 bps

Class-map: AutoQos-4.0-Signaling-Class (match-any)
  0 packets
  Match: access-group name AutoQos-4.0-Acl-Signaling
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    dscp cs3
  police:
    cir 32000 bps, bc 8000 bytes
    conformed 0 bytes; actions:
      transmit
    exceeded 0 bytes; actions:
      drop
    conformed 0000 bps, exceed 0000 bps

Class-map: AutoQos-4.0-Default-Class (match-any)
  0 packets
  Match: access-group name AutoQos-4.0-Acl-Default
    0 packets, 0 bytes
    5 minute rate 0 bps
  QoS Set
    dscp default
  police:
    cir 10000000 bps, bc 312500 bytes
    conformed 0 bytes; actions:
      transmit
    exceeded 0 bytes; actions:
      set-dscp-transmit dscp table policed-dscp
    conformed 0000 bps, exceed 0000 bps

Class-map: class-default (match-any)
  0 packets
  Match: any
    0 packets, 0 bytes
    5 minute rate 0 bps

Service-policy output: AutoQos-4.0-Output-Policy

queue stats for all priority classes:
  Queueing
  priority level 1

  (total drops) 0
  (bytes output) 0

Class-map: AutoQos-4.0-Output-Priority-Queue (match-any)
  0 packets
  Match: dscp cs4 (32) cs5 (40) ef (46)
    0 packets, 0 bytes
    5 minute rate 0 bps
  Match: cos 5
    0 packets, 0 bytes
    5 minute rate 0 bps
  Priority: 30% (300000 kbps), burst bytes 7500000,

  Priority Level: 1

Class-map: AutoQos-4.0-Output-Control-Mgmt-Queue (match-any)
  0 packets
  Match: dscp cs2 (16) cs3 (24) cs6 (48) cs7 (56)
    0 packets, 0 bytes

```

```
    5 minute rate 0 bps
Match: cos 3
    0 packets, 0 bytes
    5 minute rate 0 bps
Queueing
queue-limit dscp 16 percent 80
queue-limit dscp 24 percent 90
queue-limit dscp 48 percent 100
queue-limit dscp 56 percent 100

(total drops) 0
(bytes output) 0
bandwidth remaining 10%

queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Conf-Queue (match-any)
0 packets
Match: dscp af41 (34) af42 (36) af43 (38)
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: cos 4
    0 packets, 0 bytes
    5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Trans-Data-Queue (match-any)
0 packets
Match: dscp af21 (18) af22 (20) af23 (22)
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: cos 2
    0 packets, 0 bytes
    5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Bulk-Data-Queue (match-any)
0 packets
Match: dscp af11 (10) af12 (12) af13 (14)
    0 packets, 0 bytes
    5 minute rate 0 bps
Match: cos 1
    0 packets, 0 bytes
    5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 4%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Scavenger-Queue (match-any)
0 packets
Match: dscp cs1 (8)
```

```

    0 packets, 0 bytes
    5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 1%
queue-buffers ratio 10

Class-map: AutoQos-4.0-Output-Multimedia-Strm-Queue (match-any)
  0 packets
  Match: dscp af31 (26) af32 (28) af33 (30)
    0 packets, 0 bytes
    5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 10%
queue-buffers ratio 10

Class-map: class-default (match-any)
  0 packets
  Match: any
    0 packets, 0 bytes
    5 minute rate 0 bps
Queueing

(total drops) 0
(bytes output) 0
bandwidth remaining 25%
queue-buffers ratio 25

```

## auto qos global compact

The following is an example of the **auto qos global compact** command.

```

Device# configure terminal
Device(config)# auto qos global compact
Device(config)# interface GigabitEthernet1/2
Device(config-if)# auto qos voip cisco-phone

Device# show auto-qos

GigabitEthernet1/2
auto qos voip cisco-phone

Device# show running-config interface GigabitEthernet 1/0/2

interface GigabitEthernet1/0/2
auto qos voip cisco-phone
end

```

# Where to Go Next for Auto-QoS

Review the QoS documentation if you require any specific QoS changes to your auto-QoS configuration.

## Additional References for Auto-QoS

### Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	<i>QoS Command Reference (Catalyst 3850 Switches)</i> <i>Cisco IOS Quality of Service Solutions Command Reference</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### Standards and RFCs

Standard/RFC	Title
—	

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for Auto-QoS

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Quality of Service

Before configuring standard QoS, you must have a thorough understanding of these items:

- Standard QoS concepts.
- Wireless concepts and network topologies.
- Classic Cisco IOS QoS.
- Modular QoS CLI (MQC).
- Understanding of QoS implementation.
- The types of applications used and the traffic patterns on your network.
- Traffic characteristics and needs of your network. For example, is the traffic on your network bursty? Do you need to reserve bandwidth for voice and video streams?



- Bandwidth requirements and speed of the network.
- Location of congestion points in the network.

#### Related Topics

[Restrictions for QoS on Wired Targets](#), on page 1359

[Restrictions for QoS on Wireless Targets](#), on page 1362

## QoS Components

Quality of service (QoS) consists of the following key components:

- **Classification**— Classification is the process of distinguishing one type of traffic from another based upon access control lists (ACLs), Differentiated Services Code Point (DSCP), Class of Service (CoS), and other factors.
- **Marking and mutation**— Marking is used on traffic to convey specific information to a downstream device in the network, or to carry information from one interface in a to another. When traffic is marked, QoS operations on that traffic can be applied. This can be accomplished directly using the `set` command or through a table map, which takes input values and translates them directly to values on output.
- **Shaping and policing**— Shaping is the process of imposing a maximum rate of traffic, while regulating the traffic rate in such a way that downstream devices are not subjected to congestion. Shaping in the most common form is used to limit the traffic sent from a physical or logical interface. Policing is used to impose a maximum rate on a traffic class. If the rate is exceeded, then a specific action is taken as soon as the event occurs.
- **Queuing** — Queuing is used to prevent traffic congestion. Traffic is sent to specific queues for servicing and scheduling based upon bandwidth allocation. Traffic is then scheduled or sent out through the port.
- **Bandwidth**—Bandwidth allocation determines the available capacity for traffic that is subject to QoS policies.
- **Trust**— Trust enables traffic to pass through the , and the Differentiated Services Code Point (DSCP), precedence, or CoS values coming in from the end points are retained in the absence of any explicit policy configuration.

## QoS Terminology

The following terms are used interchangeably in this QoS configuration guide:

- Upstream (direction towards the device) is the same as ingress.
- Downstream (direction from the device) is the same as egress.



---

**Note** Upstream is wireless to wired. Downstream is wired to wireless. Wireless to wireless has no specific term.

---

# Information About QoS

## QoS Overview

By configuring the quality of service (QoS), you can provide preferential treatment to specific types of traffic at the expense of other traffic types. Without QoS, the device offers best-effort service to each packet, regardless of the packet contents or size. The device sends the packets without any assurance of reliability, delay bounds, or throughput.

The following are specific features provided by QoS:

- Low latency
- Bandwidth guarantee
- Buffering capabilities and dropping disciplines
- Traffic policing
- Enables the changing of the attribute of the frame or packet header
- Relative services

### Related Topics

[Restrictions for QoS on Wired Targets](#), on page 1359

[Restrictions for QoS on Wireless Targets](#), on page 1362

## Modular QoS Command-Line Interface

With the device, QoS features are enabled through the Modular QoS command-line interface (MQC). The MQC is a command-line interface (CLI) structure that allows you to create traffic policies and attach these policies to interfaces. A traffic policy contains a traffic class and one or more QoS features. A traffic class is used to classify traffic, while the QoS features in the traffic policy determine how to treat the classified traffic. One of the main goals of MQC is to provide a platform-independent interface for configuring QoS across Cisco platforms.

## Wireless QoS Overview

Wireless QoS can be configured on the following wireless targets:

- Wireless ports, including all physical ports to which an access point can be associated.
- Radio
- SSID (applicable on a per-radio, per-AP, and per-SSID)
- Client

From Cisco IOS XE Release 3E, marking and policing actions for ingress SSID and client policies are applied at the access point. The SSID and client ingress policies that you configure in the are moved to the access point. The access point performs policing and marking actions for each packet. However, the selects the QoS policies. Marking and policing of egress SSID and client policies are applied at the .

The following table displays how policies are supported for the wireless targets.

**Table 89: Wireless Targets Policies Support**

Wireless Target	Policies on Wireless Targets Supported	Policies Supported Egress Direction	Policies Supported Ingress Direction
Wireless port	Yes	Yes - user configurable	No
Radio	Yes	Yes - but not configurable by user	No
SSID	Yes	Yes - user configurable	Yes - user configurable
Client	Yes	Yes - user configurable	Yes - user configurable



**Note** Additional polices that are user configured include multidestination policers and VLANs.

Wireless QoS supports the following features:

- Queuing in the egress direction.
- Policing of wireless traffic
- Marking of wireless traffic.
- Shaping of wireless traffic in the egress direction.
- Approximate Fair Drop (AFD) in the egress direction.
- Mobility support for QoS.
- Compatibility with precious metal QoS policies available on Cisco Unified Wireless Controllers.
- Combination of CLI/Traffic Class (TCLAS) and CLI/snooping.
- Application control (can drop or mark the data traffic) by configuring an AVC QoS client policy.
- Drop action for ingress policies.
- QoS statistics for client and SSID targets in the ingress direction.
- QoS attribute for local profiling policy.
- Hierarchical policies.

## QoS and IPv6 for Wireless

The supports QoS for both IPv4 and IPv6 traffic, and client policies can now have IPv4 and IPv6 filters.

## Wired and Wireless Access Supported Features

The following table describes the supported features for both wired and wireless access.

**Table 90: Supported QoS Features for Wired and Wireless Access**

Feature	Wired	Wireless
Targets	<ul style="list-style-type: none"> <li>• Gigabit Ethernet</li> <li>• 10 Gigabit Ethernet</li> <li>• VLAN</li> </ul>	<ul style="list-style-type: none"> <li>• Wireless port (CAPWAP tunnel)</li> <li>• SSID</li> <li>• Client</li> <li>• Radio</li> <li>• CAPWAP multicast tunnel</li> </ul>
Configuration Sequence	QoS policy installed using the <b>service-policy</b> command.	<ul style="list-style-type: none"> <li>• When an access point joins the switch, the switch installs a policy on the port. The port policy has a child policy called <code>port_child_policy</code>.</li> <li>• A policy is installed on the radio which has a shaper configured to the radio rate. The default radio policy (which cannot be modified) is attached to the radio.</li> <li>• The default client policies take effect when a WMM client associates, and if admission control is enabled on the radio.</li> <li>• User can modify the <code>port_child_policy</code> to add more classes.</li> <li>• User can attach a user-defined policy at the SSID level.</li> <li>• User can attach a user-defined policy at the client level.</li> </ul>
Number of queues permitted at port level	Up to 8 queues supported on a port.	Only four queues supported.

Feature	Wired	Wireless
Classification mechanism	<ul style="list-style-type: none"> <li>• DSCP</li> <li>• IP precedence</li> <li>• CoS</li> <li>• QoS-group</li> <li>• ACL membership including: <ul style="list-style-type: none"> <li>• IPv4 ACLs</li> <li>• IPv6 ACLs</li> <li>• MAC ACLs</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Port level <ul style="list-style-type: none"> <li>• Ingress: QoS policies not supported on ingress in wireless ports.</li> <li>• Egress: Only DSCP based classification.</li> </ul> </li> <li>• SSID level <ul style="list-style-type: none"> <li>• Ingress: DSCP, UP</li> <li>• Egress: DSCP, COS, QoS group</li> </ul> </li> <li>• Client level <ul style="list-style-type: none"> <li>• Ingress: ACL, DSCP, UP</li> <li>• Egress: DSCP and COS</li> </ul> </li> </ul>

#### Related Topics

[Port Policy Format](#), on page 1329

## Supported QoS Features on Wireless Targets

This table describes the various features available on wireless targets.

*Table 91: QoS Features Available on Wireless Targets*

Target	Features	Traffic	Direction Where Policies Are Applicable	Comments
Port	<ul style="list-style-type: none"> <li>• Port shaper</li> <li>• Priority queuing</li> <li>• Multicast policing</li> </ul>	Non-Real Time (NRT), Real Time (RT)	Egress	
Radio	<ul style="list-style-type: none"> <li>• Shaping</li> </ul>	Non-Real Time	Egress	Radio policies are not user configurable.

Target	Features	Traffic	Direction Where Policies Are Applicable	Comments
SSID	<ul style="list-style-type: none"> <li>• Police</li> <li>• Table map</li> </ul>	Non-Real Time, Real Time	Ingress and egress	
	Shaping		Egress	
	BRR		Egress	
	Set actions <ul style="list-style-type: none"> <li>• Table map</li> <li>• set dscp</li> <li>• set cos</li> </ul>		Ingress	You can use set in both class-default and user-defined classes of SSID ingress policies.
	Set actions <ul style="list-style-type: none"> <li>• Table map</li> <li>• set dscp</li> <li>• set wlan user-priority</li> </ul>		Egress	You can define table maps only in the class-default class of an SSID policy.
	Drop		Ingress	
Client	Police	Non-Real Time, Real time	Ingress and egress	For client policies, the following filters are supported: <ul style="list-style-type: none"> <li>• ACL</li> <li>• DSCP</li> <li>• CoS (only for egress)</li> <li>• WLAN UP</li> <li>• protocol</li> </ul>
	Drop		Ingress	
	Set actions <ul style="list-style-type: none"> <li>• set dscp</li> <li>• set cos</li> </ul>		Ingress	
	Set actions <ul style="list-style-type: none"> <li>• set dscp</li> <li>• set wlan user-priority</li> </ul>		Egress	

**Related Topics**

[Port Policies](#), on page 1329

[Port Policy Format](#), on page 1329

[Radio Policies](#), on page 1331

[Applying an SSID or Client Policy on a WLAN \(CLI\)](#), on page 1380

[SSID Policies](#), on page 1331

[Configuring Client Policies \(CLI\)](#)

[Client Policies](#), on page 1331

## Port Policies



**Note** Port child policies only apply to wireless ports and not to wired ports on the switch. A wireless port is defined as a port to which APs join. A default port child policy is applied on the switch to the wireless ports at start up. The port shaper rate is limited to 1G

Port shaper specifies the traffic policy applicable between the device and the AP. This is the sum of the radio rates supported on the access point.

The child policy determines the mapping between packets and queues defined by the port-child policy. The child policy can be configured to include voice, video, class-default, and non-client-nrt classes where voice and video are based on DSCP value (which is the outer CAPWAP header DSCP value). The definition of class-default is known to the system as any value other than voice and video DSCP.

The DSCP value is assigned when the packet reaches the port. Before the packet arrives at the port, the SSID policies are applied on the packet. Port child policy also includes multicast percentage for a given port traffic. By default, the port child policy allocates up to 10 percent of the available rate.

### Related Topics

[Restrictions for QoS on Wireless Targets](#), on page 1362

[Supported QoS Features on Wireless Targets](#), on page 1327

[Examples: Wireless QoS Policy Classified by Voice, Video, and Multicast Traffic](#), on page 1419

### Port Policy Format

This section describes the behavior of the port policies on a switch. The ports on the switch do not distinguish between wired or wireless physical ports. Depending on the kind of device associated to the switch, the policies are applied. For example, when an access point is connected to a switch port, the switch detects it as a wireless device and applies the default hierarchical policy which is in the format of a parent-child policy. This policy is an hierarchical policy. The parent policy cannot be modified but the child policy (port-child policy) can be modified to suit the QoS configuration. The switch is pre configured with a default class map and a policy map.

Default class map:

```
Class Map match-any non-client-nrt-class
  Match non-client-nrt
```

The above port policy processes all network traffic to the Q3 queue. You can view the class map by executing the **show class-map** command.

Default policy map:

```
Policy Map port_child_policy
  Class non-client-nrt-class
    bandwidth remaining ratio 10
```



**Note** The class map and policy map listed are system-defined policies and cannot be changed.

The following is the system-defined policy map available on the ports on which wireless devices are associated. The format consists of a parent policy and a service child policy (**port\_child\_policy**). To customize the policies to suite your network needs, you must configure the port child policy.

```
Policy-map policy_map_name
  Class class-default
    Shape average average_rate
    Service-policy port_child_policy
```



**Note** The parent policy is system generated and cannot be changed. You must configure the *port\_child\_policy* policy to suit the QoS requirements on your network.

Depending on the type of traffic in your network, you can configure the port child policy. For example, in a typical wireless network deployment, you can assign specific priorities to voice and video traffic. Here is an example:

```
Policy-map port_child_policy
  Class voice-policy-name (match dscp ef)
    Priority level 1
    Police (multicast-policer-name-voice) Multicast Policer
  Class video-policy-name (match dscp af41)
    Priority level 2
    Police (multicast-policer-name-video) Multicast Policer
  Class non-client-nrt-class traffic(match non-client-nrt)
    Bandwidth remaining ratio (brr-value-nrt-q2)
  Class class-default (NRT Data)
    Bandwidth remaining ratio (brr-value-q3)
```

In the above port child policy:

- *voice-policy-name*— Refers to the name of the class that specifies rules for the traffic for voice packets. Here the DSCP value is mapped to a value of 46 (represented by the keyword **ef**). The voice traffic is assigned the highest priority of 1.
- *video-policy-name*— Refers to the name of the class that specifies rules for the traffic for video packets. The DSCP value is mapped to a value of 34 (represented by the keyword **af41**).
- *multicast-policer-name-voice*— If you need to configure multicast voice traffic, you can configure policing for the voice class map.
- *multicast-policer-name-video*— If you need to configure multicast video traffic, you can configure policing for the video class map.

In the above sample configuration, all voice and video traffic is directed to the Q0 and Q1 queues, respectively. These queues maintain a strict priority. The packets in Q0 and Q1 are processed in that order. The bandwidth remaining ratios *brr-value-nrt-q2* and *brr-value-q3* are directed to the Q2 and Q3 respectively specified by the class maps and *class-default* and *non-client-nrt*. The processing of packets on Q2 and Q3 are based on a weighted round-robin approach. For example, if the *brr-value-nrtq2* has a value of 90 and *brr-value-nrtq3* is 10, the packets in queue 2 and queue 3 are processed in the ratio of 9:1.

### Related Topics

- [Restrictions for QoS on Wireless Targets](#), on page 1362
- [Supported QoS Features on Wireless Targets](#), on page 1327



[Examples: Wireless QoS Policy Classified by Voice, Video, and Multicast Traffic](#), on page 1419  
[Wired and Wireless Access Supported Features](#), on page 1326  
[Policy Maps](#), on page 1341

## Radio Policies

The radio policies are system defined and are not user configurable. Radio wireless targets are only applicable in the egress direction.

Radio policies are applicable on a per-radio, per-access point basis. The rate limit on the radios is the practical limit of the AP radio rate. This value is equivalent to the sum of the radios supported by the access point.

The following radios are supported:

- 802.11 a/n
- 802.11 b/n
- 802.11 ac

### Related Topics

[Restrictions for QoS on Wireless Targets](#), on page 1362  
[Supported QoS Features on Wireless Targets](#), on page 1327

## SSID Policies

You can create QoS policies on SSID BSSID (Basic Service Set Identification) in both the ingress and egress directions. By default, there is no SSID policy. All traffic is transmitted as best effort because the wireless traffic is untrusted. You can configure an SSID policy based on the SSID name. The policy is applicable on a per BSSID.

The types of policies you can create on SSID include marking by using table maps (table-maps), shape rate, and RT1 (Real Time 1) and RT2 (Real Time 2) policers. If traffic is ingress, you usually configure a marking and policing policy on the SSID. If traffic is downstream, you can configure marking and queuing.

There should be a one-to-one mapping between the policies configured on a port and an SSID. For example, if you configure class voice and class video on the port, you can have a similar policy on the SSID.

SSID priorities can be specified by configuring bandwidth remaining ratio. Queuing SSID policies are applied in the egress direction.

### Related Topics

[Applying an SSID or Client Policy on a WLAN \(CLI\)](#), on page 1380  
[Supported QoS Features on Wireless Targets](#), on page 1327  
[Examples: SSID Policy](#)  
[Examples: Configuring Downstream SSID Policy](#), on page 1419

## Client Policies

Client policies are applicable in the ingress and egress direction. The wireless control module of the device applies the default client policies when admission control is enabled for WMM clients. When admission control is disabled, there is no default client policy. You can configure policing and marking policies on clients.



---

**Note** A client policy can have both IPv4 and IPv6 filters.

---

You can configure client policies in the following ways:

- Using AAA
- Using the Cisco IOS MQC CLI
  - You can use **service policy client** command in the WLAN configuration.
- Using the default configuration
- Using local policies (native profiling)

Use the **show wireless client mac address *mac\_address* service-policy** command to display the source of the client policy (for example, local profiling policy, AAA, or CLI). The precedence order of client policies is AAA > local policy > WLAN service client policy CLI > default configuration.



---

**Note** If you configured AAA by configuring the unified wireless controller procedure, and using the MQC QoS commands, the policy configuration performed through the MQC QoS commands takes precedence.

---



---

**Note** When applying client policies on a WLAN, you must disable the WLAN before modifying the client policy. SSID policies can be modified even if the WLAN is enabled.

---

The default client policy is enabled only on Wi-Fi Multimedia (WMM) clients that are admission control (ACM)-enabled.

### Policy Chaining

Every packet has a maximum of two applicable policies, first at the client target and second at the SSID target. The client policing action is applied to the packet before the marking action that is specified in the client policy. After the client policing and marking actions are applied to the packet, the SSID policy action is applied to the updated packet. If no custom policies are specified, the system trust configuration is applied to the packet. Egress trust is based on DSCP, and ingress trust is based on WLAN user priority.

### Related Topics

[Configuring Client Policies \(CLI\)](#)

[Supported QoS Features on Wireless Targets](#), on page 1327

[Examples: Client Policies](#), on page 1421

## Hierarchical QoS

The supports hierarchical QoS (HQoS). HQoS allows you to perform:

- Hierarchical classification—Traffic classification is based upon other classes.
- Hierarchical policing—The process of having the policing configuration at multiple levels in a hierarchical policy.

- Hierarchical shaping—Shaping can also be configured at multiple levels in the hierarchy.



**Note** Hierarchical shaping is only supported for the port shaper, where for the parent you only have a configuration for the class default, and the only action for the class default is shaping.

### Related Topics

Examples: [Hierarchical Classification](#), on page 1416

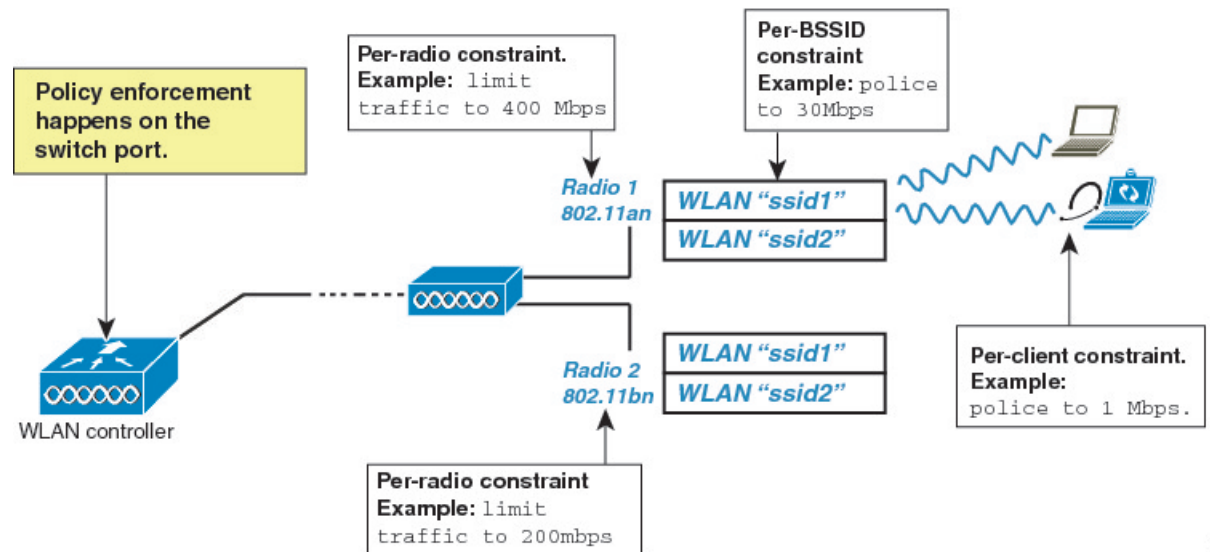
Examples: [Hierarchical Policy Configuration](#), on page 1416

## Hierarchical Wireless QoS

The device supports hierarchical QoS for wireless targets. Hierarchical QoS policies are applicable on port, radio, SSID, and client. QoS policies configured on the device (including marking, shaping, policing) can be applied across the targets. If the network contains non-realtime traffic, the non-realtime traffic is subject to approximate fair drop. Hierarchy refers to the process of application of the various QoS policies on the packets arriving to the device. You can configure policing in both the parent and child policies.



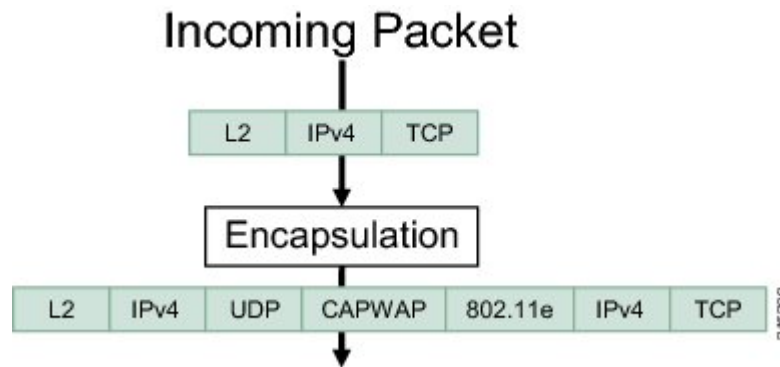
**Note** For hierarchical client and SSID policies, you only configure marking either in the parent or child policy.



## Wireless Packet Format

**Figure 93: Wireless Packet Path in the Egress Direction during First Pass**

This figure displays the wireless packet flow and encapsulation used in hierarchical wireless QoS. The incoming packet enters the device. The device encapsulates this incoming packet and adds the 802.11e and CAPWAP headers.



## Hierarchical AFD

Approximate Fair Dropping (AFD) is a feature provided by the QoS infrastructure in Cisco IOS. For wireless targets, AFD can be configured on SSID (via shaping) and clients (via policing). AFD shaping rate is only applicable for downstream direction. Unicast real-time traffic is not subjected to AFD drops.

## QoS Implementation

Typically, networks operate on a best-effort delivery basis, which means that all traffic has equal priority and an equal chance of being delivered in a timely manner. When congestion occurs, all traffic has an equal chance of being dropped.

When you configure the QoS feature, you can select specific network traffic, prioritize it according to its relative importance, and use congestion-management and congestion-avoidance techniques to provide preferential treatment. Implementing QoS in your network makes network performance more predictable and bandwidth utilization more effective.

The QoS implementation is based on the Differentiated Services (Diff-Serv) architecture, a standard from the Internet Engineering Task Force (IETF). This architecture specifies that each packet is classified upon entry into the network.

The classification is carried in the IP packet header, using 6 bits from the deprecated IP type of service (ToS) field to carry the classification (*class*) information. Classification can also be carried in the Layer 2 frame.

**Figure 94: QoS Classification Layers in Frames and Packets**

The special bits in the Layer 2 frame or a Layer 3 packet are shown in the following

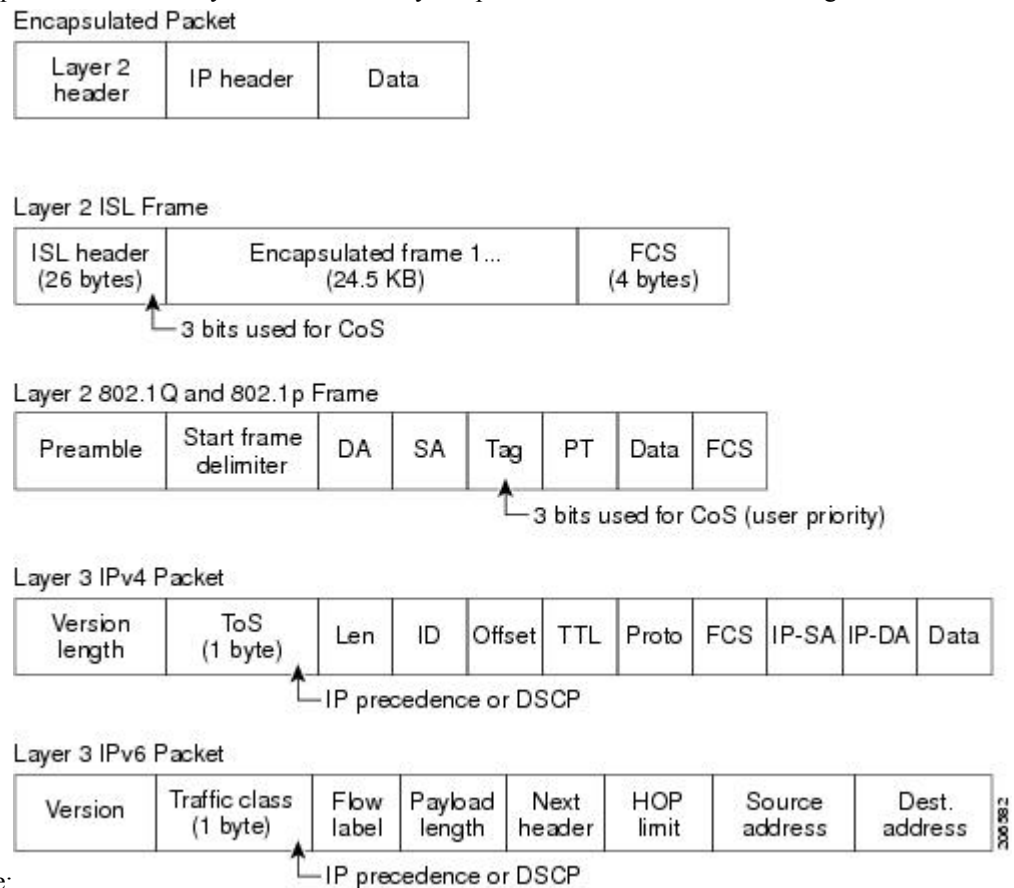


figure:

### Related Topics

[Restrictions for QoS on Wired Targets](#), on page 1359

[Restrictions for QoS on Wireless Targets](#), on page 1362

## Layer 2 Frame Prioritization Bits

Layer 2 Inter-Switch Link (ISL) frame headers have a 1-byte User field that carries an IEEE 802.1p class of service (CoS) value in the three least-significant bits. On ports configured as Layer 2 ISL trunks, all traffic is in ISL frames.

Layer 2 802.1Q frame headers have a 2-byte Tag Control Information field that carries the CoS value in the three most-significant bits, which are called the User Priority bits. On ports configured as Layer 2 802.1Q trunks, all traffic is in 802.1Q frames except for traffic in the native VLAN.

Other frame types cannot carry Layer 2 CoS values.

Layer 2 CoS values range from 0 for low priority to 7 for high priority.

## Layer 3 Packet Prioritization Bits

Layer 3 IP packets can carry either an IP precedence value or a Differentiated Services Code Point (DSCP) value. QoS supports the use of either value because DSCP values are backward-compatible with IP precedence values.

IP precedence values range from 0 to 7. DSCP values range from 0 to 63.

## End-to-End QoS Solution Using Classification

All switches and routers that access the Internet rely on the class information to provide the same forwarding treatment to packets with the same class information and different treatment to packets with different class information. The class information in the packet can be assigned by end hosts or by switches or routers along the way, based on a configured policy, detailed examination of the packet, or both. Detailed examination of the packet is expected to occur closer to the edge of the network, so that the core switches and routers are not overloaded with this task.

Switches and routers along the path can use the class information to limit the amount of resources allocated per traffic class. The behavior of an individual device when handling traffic in the Diff-Serv architecture is called per-hop behavior. If all devices along a path provide a consistent per-hop behavior, you can construct an end-to-end QoS solution.

Implementing QoS in your network can be a simple task or complex task and depends on the QoS features offered by your internetworking devices, the traffic types and patterns in your network, and the granularity of control that you need over incoming and outgoing traffic.

## Packet Classification

Packet classification is the process of identifying a packet as belonging to one of several classes in a defined policy, based on certain criteria. The Modular QoS CLI (MQC) is a policy-class based language. The policy class language is used to define the following:

- Class-map template with one or several match criteria
- Policy-map template with one or several classes associated to the policy map

The policy map template is then associated to one or several interfaces on the device.

Packet classification is the process of identifying a packet as belonging to one of the classes defined in the policy map. The process of classification will exit when the packet being processed matches a specific filter in a class. This is referred to as first-match exit. If a packet matches multiple classes in a policy, irrespective of the order of classes in the policy map, it would still exit the classification process after matching the first class.

If a packet does not match any of the classes in the policy, it would be classified into the default class in the policy. Every policy map has a default class, which is a system-defined class to match packets that do not match any of the user-defined classes.

Packet classification can be categorized into the following types:

- Classification based on information that is propagated with the packet
- Classification based on information that is device specific
- Hierarchical classification

## Classification Based on Information That is Propagated with the Packet

Classification that is based on information that is part of the packet and propagated either end-to-end or between hops, typically includes the following:

- Classification based on Layer 3 or 4 headers
- Classification based on Layer 2 information

### Classification Based on Layer 3 or Layer 4 Header

This is the most common deployment scenario. Numerous fields in the Layer 3 and Layer 4 headers can be used for packet classification.

At the most granular level, this classification methodology can be used to match an entire flow. For this deployment type, an access control list (ACLs) can be used. ACLs can also be used to match based on various subsets of the flow (for example, source IP address only, or destination IP address only, or a combination of both).

Classification can also be done based on the precedence or DSCP values in the IP header. The IP precedence field is used to indicate the relative priority with which a particular packet needs to be handled. It is made up of three bits in the IP header's type of service (ToS) byte.

The following table shows the different IP precedence bit values and their names.

**Note** IP precedence is not supported for wireless QoS.

**Table 92: IP Precedence Values and Names**

IP Precedence Value	IP Precedence Bits	IP Precedence Names
0	000	Routine
1	001	Priority
2	010	Immediate
3	011	Flash
4	100	Flash Override
5	101	Critical
6	110	Internetwork control
7	111	Network control



**Note** All routing control traffic in the network uses IP precedence value 6 by default. IP precedence value 7 also is reserved for network control traffic. Therefore, the use of IP precedence values 6 and 7 is not recommended for user traffic.

The DSCP field is made up of 6 bits in the IP header and is being standardized by the Internet Engineering Task Force (IETF) Differentiated Services Working Group. The original ToS byte contained the DSCP bits has been renamed the DSCP byte. The DSCP field is part of the IP header, similar to IP precedence. The

DSCP field is a super set of the IP precedence field. Therefore, the DSCP field is used and is set in ways similar to what was described with respect to IP precedence.




---

**Note** The DSCP field definition is backward-compatible with the IP precedence values.

---

### Classification Based on Layer 2 Header

A variety of methods can be used to perform classification based on the Layer 2 header information. The most common methods include the following:

- MAC address-based classification (only for access groups)—Classification is based upon the source MAC address (for policies in the input direction) and destination MAC address (for policies in the output direction).
- Class-of-Service—Classification is based on the 3 bits in the Layer 2 header based on the IEEE 802.1p standard. This usually maps to the ToS byte in the IP header.
- VLAN ID—Classification is based on the VLAN ID of the packet.




---

**Note** Some of these fields in the Layer 2 header can also be set using a policy.

---

### Classification Based on Information that is Device Specific (QoS Groups)

The device also provides classification mechanisms that are available where classification is not based on information in the packet header or payload.

At times you might be required to aggregate traffic coming from multiple input interfaces into a specific class in the output interface. For example, multiple customer edge routers might be going into the same access device on different interfaces. The service provider might want to police all the aggregate voice traffic going into the core to a specific rate. However, the voice traffic coming in from the different customers could have a different ToS settings. QoS group-based classification is a feature that is useful in these scenarios.

Policies configured on the input interfaces set the QoS group to a specific value, which can then be used to classify packets in the policy enabled on output interface.

The QoS group is a field in the packet data structure internal to the device. It is important to note that a QoS group is an internal label to the device and is not part of the packet header.

### Hierarchical Classification

The device permits you to perform a classification based on other classes. Typically, this action may be required when there is a need to combine the classification mechanisms (that is, filters) from two or more classes into a single class map.

## QoS Wired Model

To implement QoS, the device must perform the following tasks:

- Traffic classification—Distinguishes packets or flows from one another.



- Traffic marking and policing—Assigns a label to indicate the given quality of service as the packets move through the device, and then make the packets comply with the configured resource usage limits.
- Queuing and scheduling—Provides different treatment in all situations where resource contention exists.
- Shaping—Ensures that traffic sent from the device meets a specific traffic profile.

## Ingress Port Activity

The following activities occur at the ingress port of the device:

- Classification—Classifying a distinct path for a packet by associating it with a QoS label. For example, the device maps the CoS or DSCP in the packet to a QoS label to distinguish one type of traffic from another. The QoS label that is generated identifies all future QoS actions to be performed on this packet.
- Policing—Policing determines whether a packet is in or out of profile by comparing the rate of the incoming traffic to the configured policer. The policer limits the bandwidth consumed by a flow of traffic. The result is passed to the marker.
- Marking—Marking evaluates the policer and configuration information for the action to be taken when a packet is out of profile and determines what to do with the packet (pass through a packet without modification, mark down the QoS label in the packet, or drop the packet).



---

**Note** Applying polices on the wireless ingress port is not supported on the device.

---

## Egress Port Activity

The following activities occur at the egress port of the device:

- Policing—Policing determines whether a packet is in or out of profile by comparing the rate of the incoming traffic to the configured policer. The policer limits the bandwidth consumed by a flow of traffic. The result is passed to the marker.
- Marking—Marking evaluates the policer and configuration information for the action to be taken when a packet is out of profile and determines what to do with the packet (pass through a packet without modification, mark down the QoS label in the packet, or drop the packet).
- Queueing—Queueing evaluates the QoS packet label and the corresponding DSCP or CoS value before selecting which of the egress queues to use. Because congestion can occur when multiple ingress ports simultaneously send data to an egress port, Weighted Tail Drop (WTD) differentiates traffic classes and subjects the packets to different thresholds based on the QoS label. If the threshold is exceeded, the packet is dropped.

## Classification

Classification is the process of distinguishing one kind of traffic from another by examining the fields in the packet. Classification is enabled only if QoS is enabled on the . By default, QoS is enabled on the .

During classification, the performs a lookup and assigns a QoS label to the packet. The QoS label identifies all QoS actions to be performed on the packet and from which queue the packet is sent.

## Access Control Lists

You can use IP standard, IP extended, or Layer 2 MAC ACLs to define a group of packets with the same characteristics (class). You can also classify IP traffic based on IPv6 ACLs.

In the QoS context, the permit and deny actions in the access control entries (ACEs) have different meanings from security ACLs:

- If a match with a permit action is encountered (first-match principle), the specified QoS-related action is taken.
- If a match with a deny action is encountered, the ACL being processed is skipped, and the next ACL is processed.




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**Note** Deny action is supported in Cisco IOS Release 3.7.4E and later releases.

---

- If no match with a permit action is encountered and all the ACEs have been examined, no QoS processing occurs on the packet, and the offers best-effort service to the packet.
- If multiple ACLs are configured on a port, the lookup stops after the packet matches the first ACL with a permit action, and QoS processing begins.




---

**Note** When creating an access list, note that by default the end of the access list contains an implicit deny statement for everything if it did not find a match before reaching the end.

---

After a traffic class has been defined with the ACL, you can attach a policy to it. A policy might contain multiple classes with actions specified for each one of them. A policy might include commands to classify the class as a particular aggregate (for example, assign a DSCP) or rate-limit the class. This policy is then attached to a particular port on which it becomes effective.

You implement IP ACLs to classify IP traffic by using the **access-list** global configuration command; you implement Layer 2 MAC ACLs to classify non-IP traffic by using the **mac access-list extended** global configuration command.

## Class Maps

A class map is a mechanism that you use to name a specific traffic flow (or class) and isolate it from all other traffic. The class map defines the criteria used to match against a specific traffic flow to further classify it. The criteria can include matching the access group defined by the ACL or matching a specific list of DSCP or IP precedence values. If you have more than one type of traffic that you want to classify, you can create another class map and use a different name. After a packet is matched against the class-map criteria, you further classify it through the use of a policy map.

You create a class map by using the **class-map** global configuration command or the **class** policy-map configuration command. You should use the **class-map** command when the map is shared among many ports. When you enter the **class-map** command, the enters the class-map configuration mode. In this mode, you define the match criterion for the traffic by using the **match** class-map configuration command.

You can create a default class by using the **class class-default** policy-map configuration command. The default class is system-defined and cannot be configured. Unclassified traffic (traffic that does not meet the match criteria specified in the traffic classes) is treated as default traffic.

#### Related Topics

[Creating a Traffic Class \(CLI\)](#), on page 1365

[Examples: Classification by Access Control Lists](#), on page 1414

## Policy Maps

A policy map specifies which traffic class to act on. Actions can include the following:

- Setting a specific DSCP or IP precedence value in the traffic class
- Setting a CoS value in the traffic class
- Setting a QoS group
- Setting a wireless LAN (WLAN) value in the traffic class
- Specifying the traffic bandwidth limitations and the action to take when the traffic is out of profile

Before a policy map can be effective, you must attach it to a port.

You create and name a policy map using the **policy-map** global configuration command. When you enter this command, the router enters the policy-map configuration mode. In this mode, you specify the actions to take on a specific traffic class by using the **class** or **set** policy-map configuration and policy-map class configuration commands.

The policy map can also be configured using the **police** and **bandwidth** policy-map class configuration commands, which define the policer, the bandwidth limitations of the traffic, and the action to take if the limits are exceeded. In addition, the policy-map can further be configured using the **priority** policy-map class configuration command, to schedule priority for the class or the queueing policy-map class configuration commands, **queue-buffers** and **queue-limit**.

To enable the policy map, you attach it to a port by using the **service-policy** interface configuration command.



**Note** You cannot configure both **priority** and **set** for a policy map. If both these commands are configured for a policy map, and when the policy map is applied to an interface, error messages are displayed. The following example shows this restriction:

```
Switch# configure terminal
Switch(config)# class-map cmap
Switch(config-cmap)# exit
Switch(config)# class-map classmap1
Switch(config-cmap)# exit
Switch(config)# policy-map pmap
Switch(config-pmap)# class cmap
Switch(config-pmap-c)# priority
Switch(config-pmap-c)# exit
Switch(config-pmap)# class classmap1
Switch(config-pmap-c)# set
Switch(config-pmap-c)# exit
Switch(config-pmap)# exit
Switch(config)# interface gigabitethernet 0/1/1
Switch(config-if)# service-policy output pmap

Non-queuing action only is unsupported in a queuing policy!!!
%QOS-6-POLICY_INST_FAILED:
Service policy installation failed
```

### Related Topics

[Creating a Traffic Policy \(CLI\)](#), on page 1368

[Port Policy Format](#), on page 1329

## Policy Map on Physical Port

You can configure a nonhierarchical policy map on a physical port that specifies which traffic class to act on. Actions can include setting a specific DSCP or IP precedence value in the traffic class, specifying the traffic bandwidth limitations for each matched traffic class (policer), and taking action when the traffic is out of profile (marking).

A policy map also has these characteristics:

- A policy map can contain multiple class statements, each with different match criteria and policers.
- A policy map can contain a predefined default traffic class explicitly placed at the end of the map.

When you configure a default traffic class by using the **class class-default** policy-map configuration command, unclassified traffic (traffic that does not meet the match criteria specified in the traffic classes) is treated as the default traffic class (**class-default**).

- A separate policy-map class can exist for each type of traffic received through a port.

### Related Topics

[Attaching a Traffic Policy to an Interface \(CLI\)](#), on page 1379

## Policy Map on VLANs

The `service-policy` supports a VLAN QoS feature that allows the user to perform QoS treatment at the VLAN level (classification and QoS actions) using the incoming frame's VLAN information. In VLAN-based QoS, a service policy is applied to an SVI interface. All physical interfaces belonging to a VLAN policy map then need to be programmed to refer to the VLAN-based policy maps instead of the port-based policy map.

Although the policy map is applied to the VLAN SVI, any policing (rate-limiting) action can only be performed on a per-port basis. You cannot configure the policer to take account of the sum of traffic from a number of physical ports. Each port needs to have a separate policer governing the traffic coming into that port.

#### Related Topics

[Classifying, Policing, and Marking Traffic on SVIs by Using Policy Maps \(CLI\)](#), on page 1384

[Examples: Policer VLAN Configuration](#), on page 1426

## Wireless QoS Multicast

You can configure multicast policing rate at the port level.

#### Related Topics

[Examples: Wireless QoS Policy Classified by Voice, Video, and Multicast Traffic](#), on page 1419

## Policing

After a packet is classified and has a DSCP-based, CoS-based, or QoS-group label assigned to it, the policing and marking process can begin.

Policing involves creating a policer that specifies the bandwidth limits for the traffic. Packets that exceed the limits are *out of profile* or *nonconforming*. Each policer decides on a packet-by-packet basis whether the packet is in or out of profile and specifies the actions on the packet. These actions, carried out by the marker, include passing through the packet without modification, dropping the packet, or modifying (marking down) the assigned DSCP or CoS value of the packet and allowing the packet to pass through.

To avoid out-of-order packets, both conform and nonconforming traffic typically exit the same queue.



---

**Note** All traffic, regardless of whether it is bridged or routed, is subjected to a policer, if one is configured. As a result, bridged packets might be dropped or might have their DSCP or CoS fields modified when they are policed and marked.

---

You can only configure policing on a physical port.

After you configure the policy map and policing actions, attach the policy to an ingress port or SVI by using the **service-policy** interface configuration command.

#### Related Topics

[Configuring Police \(CLI\)](#), on page 1399

[Examples: Policing Action Configuration](#), on page 1425

## Token-Bucket Algorithm

Policing uses a token-bucket algorithm. As each frame is received by the device, a token is added to the bucket. The bucket has a hole in it and leaks at a rate that you specify as the average traffic rate in bits per second. Each time a token is added to the bucket, the device verifies that there is enough room in the bucket. If there is not enough room, the packet is marked as nonconforming, and the specified policer action is taken (dropped or marked down).

How quickly the bucket fills is a function of the bucket depth (burst-byte), the rate at which the tokens are removed (rate-bps), and the duration of the burst above the average rate. The size of the bucket imposes an upper limit on the burst length and limits the number of frames that can be transmitted back-to-back. If the

burst is short, the bucket does not overflow, and no action is taken against the traffic flow. However, if a burst is long and at a higher rate, the bucket overflows, and the policing actions are taken against the frames in that burst.

You configure the bucket depth (the maximum burst that is tolerated before the bucket overflows) by using the burst-byte option of the **police** policy-map class configuration command. You configure how fast (the average rate) that the tokens are removed from the bucket by using the rate option of the **police** policy-map class configuration command.

#### Related Topics

[Configuring Police \(CLI\)](#), on page 1399

[Examples: Policing Units](#)

## Marking

Marking is used to convey specific information to a downstream device in the network, or to carry information from one interface in a device to another.

Marking can be used to set certain field/bits in the packet headers, or marking can also be used to set certain fields in the packet structure that is internal to the device. Additionally, the marking feature can be used to define mapping between fields. The following marking methods are available for QoS:

- Packet header
- Device ) specific information
- Table maps

### Packet Header Marking

Marking on fields in the packet header can be classified into two general categories:

- IPv4/v6 header bit marking
- Layer 2 header bit marking

The marking feature at the IP level is used to set the precedence or the DSCP in the IP header to a specific value to get a specific per-hop behavior at the downstream device (switch or router), or it can also be used to aggregate traffic from different input interfaces into a single class in the output interface. The functionality is currently supported on both the IPv4 and IPv6 headers.

Marking in the Layer 2 headers is typically used to influence dropping behavior in the downstream devices (switch or router). It works in tandem with the match on the Layer 2 headers. The bits in the Layer 2 header that can be set using a policy map are class of service.

### Switch Specific Information Marking

This form of marking includes marking of fields in the packet data structure that are not part of the packets header, so that the marking can be used later in the data path. This is not propagated between the switches. Marking of QoS-group falls into this category. This form of marking is only supported in policies that are enabled on the input interfaces. The corresponding matching mechanism can be enabled on the output interfaces on the same switch and an appropriate QoS action can be applied.

## Table Map Marking



**Note** QoS marking is not supported on the 802.11ac Wave 2 APs. This is because table-maps used for QoS marking are not supported on the 802.11ac Wave 2 APs.

Table map marking enables the mapping and conversion from one field to another using a conversion table. This conversion table is called a table map.

Depending upon the table map attached to an interface, CoS, DSCP, and UP values (UP specific to wireless packets) of the packet are rewritten. The device allows configuring both ingress table map policies and egress table map policies.



**Note** The device stack supports a total of 14 table maps. Only one table map is supported per wired port, per direction.

As an example, a table map can be used to map the Layer 2 CoS setting to a precedence value in Layer 3. This feature enables combining multiple **set** commands into a single table, which indicates the method to perform the mapping. This table can be referenced in multiple policies, or multiple times in the same policy.

The following table shows the currently supported forms of mapping:

**Table 93: Packet-Marking Types Used for Establishing a To-From Relationship**

The To Packet-Marking Type	The From Packet-Marking Type
Precedence	CoS
Precedence	QoS Group
DSCP	CoS
DSCP	QoS Group
CoS	Precedence
CoS	DSCP
QoS Group	Precedence
QoS Group	DSCP

A table map-based policy supports the following capabilities:

- Mutation—You can have a table map that maps from one DSCP value set to another DSCP value set, and this can be attached to an egress port.
- Rewrite—Packets coming in are rewritten depending upon the configured table map.
- Mapping—Table map based policies can be used instead of set policies.

The following steps are required for table map marking:

1. Define the table map—Use the **table-map** global configuration command to map the values. The table does not know of the policies or classes within which it will be used. The default command in the table map is used to indicate the value to be copied into the to field when there is no matching from field.
2. Define the policy map—You must define the policy map where the table map will be used.
3. Associate the policy to an interface.



**Note** A table map policy on an input port changes the trust setting of that port to the from type of qos-marking.

#### Related Topics

[Configuring Table Maps \(CLI\)](#), on page 1387

[Examples: Table Map Marking Configuration](#), on page 1428

## Traffic Conditioning

To support QoS in a network, traffic entering the service provider network needs to be policed on the network boundary routers to ensure that the traffic rate stays within the service limit. Even if a few routers at the network boundary start sending more traffic than what the network core is provisioned to handle, the increased traffic load leads to network congestion. The degraded performance in the network makes it difficult to deliver QoS for all the network traffic.

Traffic policing functions (using the police feature) and shaping functions (using the traffic shaping feature) manage the traffic rate, but differ in how they treat traffic when tokens are exhausted. The concept of tokens comes from the token bucket scheme, a traffic metering function.



**Note** When running QoS tests on network traffic, you may see different results for the shaper and policing data. Network traffic data from shaping provides more accurate results.

This table compares the policing and shaping functions.

**Table 94: Comparison Between Policing and Shaping Functions**

Policing Function	Shaping Function
Sends conforming traffic up to the line rate and allows bursts.	Smooths traffic and sends it out at a constant rate.
When tokens are exhausted, action is taken immediately.	When tokens are exhausted, it buffers packets and sends them out later, when tokens are available. A class with shaping has a queue associated with it which will be used to buffer the packets.
Policing has multiple units of configuration – in bits per second, packets per second and cells per second.	Shaping has only one unit of configuration - in bits per second.



Policing Function	Shaping Function
Policing has multiple possible actions associated with an event, marking and dropping being example of such actions.	Shaping does not have the provision to mark packets that do not meet the profile.
Works for both input and output traffic.	Implemented for output traffic only.
Transmission Control Protocol (TCP) detects the line at line speed but adapts to the configured rate when a packet drop occurs by lowering its window size.	TCP can detect that it has a lower speed line and adapt its retransmission timer accordingly. This results in less scope of retransmissions and is TCP-friendly.

## Policing

The QoS policing feature is used to impose a maximum rate on a traffic class. The QoS policing feature can also be used with the priority feature to restrict priority traffic. If the rate is exceeded, then a specific action is taken as soon as the event occurs. The rate (committed information rate [CIR] and peak information rate [PIR] ) and the burst parameters (conformed burst size [  $B_c$  ] and extended burst size [  $B_e$  ] ) are all configured in bytes per second.

The following policing forms or policers are supported for QoS:

- Single-rate two-color policing
- Dual-rate three-color policing



**Note** Single-rate three-color policing is not supported.

### Single-Rate Two-Color Policing

Single-rate two-color policer is the mode in which you configure only a CIR and a  $B_c$ .

The  $B_c$  is an optional parameter, and if it is not specified it is computed by default. In this mode, when an incoming packet has enough tokens available, the packet is considered to be conforming. If at the time of packet arrival, enough tokens are not available within the bounds of  $B_c$ , the packet is considered to have exceeded the configured rate.



**Note** For information about the token-bucket algorithm, see [Token-Bucket Algorithm, on page 1343](#).

#### Related Topics

[Configuring Police \(CLI\)](#), on page 1399

[Examples: Single-Rate Two-Color Policing Configuration](#), on page 1427

### Dual-Rate Three-Color Policing

With the dual rate policer, the device supports only color-blind mode. In this mode, you configure a committed information rate (CIR) and a peak information rate (PIR). As the name suggests, there are two token buckets in this case, one for the peak rate, and one for the conformed rate.




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**Note** For information about the token-bucket algorithm, see [Token-Bucket Algorithm, on page 1343](#).

---

In the color-blind mode, the incoming packet is first checked against the peak rate bucket. If there are not enough tokens available, the packet is said to violate the rate. If there are enough tokens available, then the tokens in the conformed rate buckets are checked to determine if there are enough tokens available. The tokens in the peak rate bucket are decremented by the size of the packet. If it does not have enough tokens available, the packet is said to have exceeded the configured rate. If there are enough tokens available, then the packet is said to conform, and the tokens in both the buckets are decremented by the size of the packet.

The rate at which tokens are replenished depends on the packet arrival. Assume that a packet comes in at time T1 and the next one comes in at time T2. The time interval between T1 and T2 determines the number of tokens that need to be added to the token bucket. This is calculated as:

Time interval between packets (T2-T1) \* CIR)/8 bytes

#### Related Topics

[Configuring Police \(CLI\)](#), on page 1399

[Examples: Dual-Rate Three-Color Policing Configuration](#), on page 1427

## Shaping

Shaping is the process of imposing a maximum rate of traffic, while regulating the traffic rate in such a way that the downstream switches and routers are not subjected to congestion. Shaping in the most common form is used to limit the traffic sent from a physical or logical interface.

Shaping has a buffer associated with it that ensures that packets which do not have enough tokens are buffered as opposed to being immediately dropped. The number of buffers available to the subset of traffic being shaped is limited and is computed based on a variety of factors. The number of buffers available can also be tuned using specific QoS commands. Packets are buffered as buffers are available, beyond which they are dropped.

### Class-Based Traffic Shaping

The uses class-based traffic shaping. This shaping feature is enabled on a class in a policy that is associated to an interface. A class that has shaping configured is allocated a number of buffers to hold the packets that do not have tokens. The buffered packets are sent out from the class using FIFO. In the most common form of usage, class-based shaping is used to impose a maximum rate for an physical interface or logical interface as a whole. The following shaping forms are supported in a class:

- Average rate shaping
- Hierarchical shaping

Shaping is implemented using a token bucket. The values of CIR, B<sub>c</sub> and B<sub>e</sub> determine the rate at which the packets are sent out and the rate at which the tokens are replenished.




---

**Note** For information about the token-bucket algorithm, see [Token-Bucket Algorithm, on page 1343](#).

---

#### Average Rate Shaping

You use the **shape average** policy-map class command to configure average rate shaping.

This command configures a maximum bandwidth for a particular class. The queue bandwidth is restricted to this value even though the port has more bandwidth available. The `shape` supports configuring shape average by either a percentage or by a target bit rate value.

**Related Topics**

[Configuring Shaping \(CLI\)](#), on page 1409

[Examples: Average Rate Shaping Configuration](#), on page 1423

*Hierarchical Shaping*

Shaping can also be configured at multiple levels in a hierarchy. This is accomplished by creating a parent policy with shaping configured, and then attaching child policies with additional shaping configurations to the parent policy.

There are two supported types of hierarchical shaping:

- Port shaper
- User-configured shaping

The port shaper uses the class default and the only action permitted in the parent is shaping. The queuing action is in the child with the port shaper. With the user configured shaping, you cannot have queuing action in the child.

**Related Topics**

[Configuring Shaping \(CLI\)](#), on page 1409

## Queueing and Scheduling

The `queue` uses both queuing and scheduling to help prevent traffic congestion. The `queue` supports the following queuing and scheduling features:

- Bandwidth
- Weighted Tail Drop
- Priority queues
- Queue buffers

When you define a queuing policy on a port, control packets are mapped to the best priority queue with the highest threshold. Control packets queue mapping works differently in the following scenarios:

- Without a quality of service (QoS) policy—If no QoS policy is configured, control packets with DSCP values 16, 24, 48, and 56 are mapped to queue 0 with the highest threshold of `threshold2`.
- With an user-defined policy—An user-defined queuing policy configured on egress ports can affect the default priority queue setting on control packets.

Control traffic is redirected to the best queue based on the following rules:

1. If defined in a user policy, the highest- level priority queue is always chosen as the best queue.
2. In the absence of a priority queue, Cisco IOS software selects queue 0 as the best queue. When the software selects queue 0 as the best queue, you must define the highest bandwidth to this queue to get the best QoS treatment to the control plane traffic.

3. If thresholds are not configured on the best queue, Cisco IOS software assigns control packets with Differentiated Services Code Point (DSCP) values 16, 24, 48, and 56 are mapped to threshold2 and reassigns the rest of the control traffic in the best queue to threshold1.

If a policy is not configured explicitly for control traffic, the Cisco IOS software maps all unmatched control traffic to the best queue with threshold2, and the matched control traffic is mapped to the queue as configured in the policy.




---

**Note** To provide proper QoS for Layer 3 packets, you must ensure that packets are explicitly classified into appropriate queues. When the software detects DSCP values in the default queue, then it automatically reassigns this queue as the best queue.

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## Bandwidth

The supports the following bandwidth configurations:

- Bandwidth percent
- Bandwidth remaining ratio

### Related Topics

[Configuring Bandwidth \(CLI\)](#), on page 1397

## Bandwidth Percent

You can use the **bandwidth percent** policy-map class command to allocate a minimum bandwidth to a particular class. The total sum cannot exceed 100 percent and in case the total sum is less than 100 percent, then the rest of the bandwidth is divided equally among all bandwidth queues.




---

**Note** A queue can oversubscribe bandwidth in case the other queues do not utilize the entire port bandwidth.

---

You cannot mix bandwidth types on a policy map. For example, you cannot configure bandwidth in a single policy map using both a bandwidth percent and in kilobits per second.

## Bandwidth Remaining Ratio

You use the **bandwidth remaining ratio** policy-map class command to create a ratio for sharing unused bandwidth in specified queues. Any unused bandwidth will be used by these specific queues in the ratio that is specified by the configuration. Use this command when the **priority** command is also used for certain queues in the policy.

When you assign ratios, the queues will be assigned certain weights which are inline with these ratios.

You can specify ratios using a range from 0 to 100. For example, you can configure a bandwidth remaining ratio of 2 on one class, and another queue with a bandwidth remaining ratio of 4 on another class. The bandwidth remaining ratio of 4 will be scheduled twice as often as the bandwidth remaining ratio of 2.

The total bandwidth ratio allocation for the policy can exceed 100. For example, you can configure a queue with a bandwidth remaining ratio of 50, and another queue with a bandwidth remaining ratio of 100.

## Weighted Tail Drop

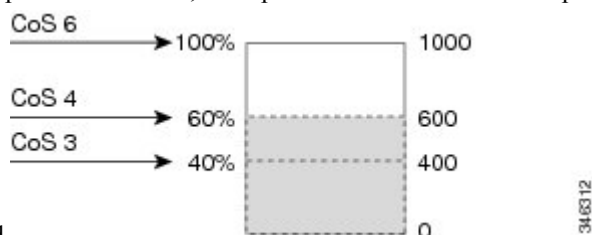
The egress queues use an enhanced version of the tail-drop congestion-avoidance mechanism called weighted tail drop (WTD). WTD is implemented on queues to manage the queue lengths and to provide drop precedences for different traffic classifications.

As a frame is enqueued to a particular queue, WTD uses the frame's assigned QoS label to subject it to different thresholds. If the threshold is exceeded for that QoS label (the space available in the destination queue is less than the size of the frame), the drops the frame.

Each queue has three configurable threshold values. The QoS label determines which of the three threshold values is subjected to the frame.

**Figure 95: WTD and Queue Operation**

The following figure shows an example of WTD operating on a queue whose size is 1000 frames. Three drop percentages are configured: 40 percent (400 frames), 60 percent (600 frames), and 100 percent (1000 frames). These percentages indicate that up to 400 frames can be queued at the 40-percent threshold, up to 600 frames at the 60-percent threshold, and up to 1000 frames at the 100-percent



threshold.

In the example, CoS value 6 has a greater importance than the other CoS values, and is assigned to the 100-percent drop threshold (queue-full state). CoS values 4 is assigned to the 60-percent threshold, and CoS values 3 is assigned to the 40-percent threshold. All of these threshold values are assigned using the **queue-limit cos** command.

Assuming the queue is already filled with 600 frames, and a new frame arrives. It contains CoS value 4 and is subjected to the 60-percent threshold. If this frame is added to the queue, the threshold will be exceeded, so the drops it.

### Related Topics

[Configuring Queue Limits \(CLI\)](#), on page 1406

[Examples: Queue-limit Configuration](#), on page 1424

### Weighted Tail Drop Default Values

The following are the Weighted Tail Drop (WTD) default values and the rules for configuring WTD threshold values.

- If you configure less than three queue-limit percentages for WTD, then WTD default values are assigned to these thresholds.

The following are the WTD threshold default values:

**Table 95: WTD Threshold Default Values**

Threshold	Default Value Percentage
0	80

Threshold	Default Value Percentage
1	90
2	400

- If 3 different WTD thresholds are configured, then the queues are programmed as configured.
- If 2 WTD thresholds are configured, then the maximum value percentage will be 400.
- If a WTD single threshold is configured as x, then the maximum value percentage will be 400.
  - If the value of x is less than 90, then threshold1=90 and threshold 0= x.
  - If the value of x equals 90, then threshold1=90, threshold 0=80.
  - If the value x is greater than 90, then threshold1=x, threshold 0=80.

## Priority Queues

Each port supports eight egress queues, of which two can be given a priority.

You use the **priority level** policy class-map command to configure the priority for two classes. One of the classes has to be configured with a priority queue level 1, and the other class has to be configured with a priority queue level 2. Packets on these two queues are subjected to less latency with respect to other queues.



**Note** You can configure a priority only with a level.

Only one strict priority or a priority with levels is allowed in one policy map. Multiple priorities with the same priority levels without kbps/percent are allowed in a policy map only if all of them are configured with police.

### Related Topics

[Configuring Priority \(CLI\)](#), on page 1402

## Queue Buffer

In Cisco IOS XE Release 3.7.5 E and later releases, all downlink ports are allocated 1 GB port buffer, even though the downlink port size is 10GB. Prior to this change, all 1 GB downlink ports had 1 GB buffer and 10 GB downlink ports had 10 GB buffer.

At boot time, when there is no policy map enabled on the wired port, there are two queues created by default. Wired ports can have a maximum of 8 queues configured using MQC-based policies. The following table shows which packets go into which one of the queues:

**Table 96: DSCP, Precedence, and CoS - Queue Threshold Mapping Table**

DSCP, Precedence or CoS	Queue	Threshold
Control Packets	0	2
Rest of Packets	1	2



**Note** You can guarantee the availability of buffers, set drop thresholds, and configure the maximum memory allocation for a queue. You use the **queue-buffers** policy-map class command to configure the queue buffers. You use the **queue-limit** policy-map class command to configure the maximum thresholds.

There are two types of buffer allocations: hard buffers, which are explicitly reserved for the queue, and soft buffers, which are available for other ports when unused by a given port.

For the wireless port default, Queue 0 will be given 40 percent of the buffers that are available for the interface as hard buffers, that is 67 buffers are allocated for Queue 0 in the context of 1-gigabit ports. The soft maximum for this queue is set to 268 (calculated as  $67 * 400/100$ ) for 1-gigabit ports, where 400 is the default maximum threshold that is configured for any queue.

For the wired port default, Queue 0 will be given 40 percent of the buffers that are available for the interface as hard buffers, that is 120 buffers are allocated for Queue 0 in the context of 1-gigabit ports, and 720 buffers in the context of 10-gigabit ports. The soft maximum for this queue is set to 480 (calculated as  $120 * 400/100$ ) for 1-gigabit ports and 2880 for 10-gigabit ports, where 400 is the default maximum threshold that is configured for any queue.

## Queue Buffer Allocation

The buffer allocation to any queue can be tuned using the **queue-buffers ratio** policy-map class configuration command.

### Related Topics

[Configuring Queue Buffers \(CLI\)](#), on page 1404

[Examples: Queue Buffers Configuration](#), on page 1425

## Dynamic Threshold and Scaling

Traditionally, reserved buffers are statically allocated for each queue. No matter whether the queue is active or not, its buffers are held up by the queue. In addition, as the number of queues increases, the portion of the reserved buffers allocated for each queue can become smaller and smaller. Eventually, a situation may occur where there are not enough reserved buffers to support a jumbo frame for all queues.

The device supports Dynamic Thresholding and Scaling (DTS), which is a feature that provides a fair and efficient allocation of buffer resources. When congestion occurs, this DTS mechanism provides an elastic buffer allocation for the incoming data based on the occupancy of the global/port resources. Conceptually, DTS scales down the queue buffer allocation gradually as the resources are used up to leave room for other queues, and vice versa. This flexible method allows the buffers to be more efficiently and fairly utilized.

As mentioned in the previous sections, there are two limits configured on a queue—a hard limit and a soft limit.

Hard limits are not part of DTS. These buffers are available only for that queue. The sum of the hard limits should be less than the globally set up hard maximum limit. The global hard limit configured for egress queuing is currently set to 5705. In the default scenario when there are no MQC policies configured, the 24 1-gigabit ports would take up  $24 * 67 = 1608$ , and the 4 10-gigabit ports would take up  $4 * 720 = 2880$ , for a total of 4488 buffers, allowing room for more hard buffers to be allocated based upon the configuration.

Soft limit buffers participate in the DTS process. Additionally, some of the soft buffer allocations can exceed the global soft limit allocation. The global soft limit allocation for egress queuing is currently set to 7607. The sum of the hard and soft limits add up to 13312, which in turn translates to 3.4 MB. Because the sum of the soft buffer allocations can exceed the global limit, it allows a specific queue to use a large number of

buffers when the system is lightly loaded. The DTS process dynamically adjusts the per-queue allocation as the system becomes more heavily loaded.

## Queuing in Wireless

Queuing in the wireless component is performed based on the port policy and is applicable only in the downstream direction. The wireless module supports the following four queues:

- **Voice**—This is a strict priority queue. Represented by Q0, this queue processes control traffic and multicast or unicast voice traffic. All control traffic (such as CAPWAP packets) is processed through the voice queue. The QoS module uses a different threshold within the voice queue to process control and voice packets to ensure that control packets get higher priority over other non-control packets.
- **Video**—This is a strict priority queue. Represented by Q1, this queue processes multicast or unicast video traffic.
- **Data NRT**—Represented by Q2, this queue processes all non-real-time unicast traffic.
- **Multicast NRT**—Represented by Q3, this queue processes Multicast NRT traffic. Any traffic that does not match the traffic in Q0, Q1, or Q2 is processed through Q3.




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**Note** By default, the queues Q0 and Q1 are not enabled.

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**Note** A weighted round-robin policy is applied for traffic in the queues Q2 and Q3.

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For upstream direction only one queue is available. Port and radio policies are applicable only in the downstream direction.




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**Note** The wired ports support eight queues.

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## Trust Behavior

### Trust Behavior for Wired and Wireless Ports

For wired or wireless ports that are connected to the device (end points such as IP phones, laptops, cameras, telepresence units, or other devices), their DSCP, precedence, or CoS values coming in from these end points are trusted by the device and therefore are retained in the absence of any explicit policy configuration.

This trust behavior is applicable to both upstream and downstream QoS.

The packets are enqueued to the appropriate queue per the default initial configuration. No priority queuing at the device is done by default. This is true for unicast and multicast packets.

In scenarios where the incoming packet type differs from the outgoing packet type, the trust behavior and the queuing behavior are explained in the following table. Note that the default trust mode for a port is DSCP based. The trust mode ‘falls back’ to CoS if the incoming packet is a pure Layer 2 packet. You can also change the trust setting from DSCP to CoS. This setting change is accomplished by using an MQC policy that has a



class default with a 'set cos cos table default default-cos' action, where default-cos is the name of the table map created (which only performs a default copy).

**Table 97: Trust and Queuing Behavior**

Incoming Packet	Outgoing Packet	Trust Behavior	Queuing Behavior
Layer 3	Layer 3	Preserve DSCP/Precedence	Based on DSCP
Layer 2	Layer 2	Not applicable	Based on CoS
Tagged	Tagged	Preserve DSCP and CoS	Based on DSCP (trust DSCP takes precedence)
Layer 3	Tagged	Preserve DSCP, CoS is set to 0	Based on DSCP

The Cisco IOS XE 3.2 Release supported different trust defaults for wired and wireless ports. The trust default for wired ports was the same as for this software release. For wireless ports, the default system behavior was non-trust, which meant that when the device came up, all markings for the wireless ports were defaulted to zero and no traffic received priority treatment. For compatibility with an existing wired device, all traffic went to the best-effort queue by default. The access point performed priority queuing by default. In the downstream direction, the access point maintained voice, video, best-effort, and background queues for queuing. The access selected the queuing strategy based on the 11e tag information. By default, the access point treated all wireless packets as best effort.

#### Related Topics

[Configuring Trust Behavior for Wireless Traffic \(CLI\)](#), on page 1390

[Example: Table Map Configuration to Retain CoS Markings](#), on page 1429

## Port Security on a Trusted Boundary for Cisco IP Phones

In a typical network, you connect a Cisco IP Phone to a device port and cascade devices that generate data packets from the back of the telephone. The Cisco IP Phone guarantees the voice quality through a shared data link by marking the CoS level of the voice packets as high priority (CoS = 5) and by marking the data packets as low priority (CoS = 0). Traffic sent from the telephone to the device is typically marked with a tag that uses the 802.1Q header. The header contains the VLAN information and the class of service (CoS) 3-bit field, which is the priority of the packet.

For most Cisco IP Phone configurations, the traffic sent from the telephone to the device should be trusted to ensure that voice traffic is properly prioritized over other types of traffic in the network. By using the **trust device** interface configuration command, you configure the device port to which the telephone is connected to trust the traffic received on that port.



**Note** The **trust device** *device\_type* command available in interface configuration mode is a stand-alone command on the device. When using this command in an AutoQoS configuration, if the connected peer device is not a corresponding device (defined as a device matching your trust policy), both CoS and DSCP values are set to "0" and any input policy will not take effect. If the connected peer device is a corresponding device, input policy will take effect.

With the trusted setting, you also can use the trusted boundary feature to prevent misuse of a high-priority queue if a user bypasses the telephone and connects the PC directly to the device. Without trusted boundary, the CoS labels generated by the PC are trusted by the device (because of the trusted CoS setting). By contrast, trusted boundary uses CDP to detect the presence of a Cisco IP Phone (such as the Cisco IP Phone 7910, 7935, 7940, and 7960) on a device port. If the telephone is not detected, the trusted boundary feature disables the trusted setting on the device port and prevents misuse of a high-priority queue. Note that the trusted boundary feature is not effective if the PC and Cisco IP Phone are connected to a hub that is connected to the device.

#### Related Topics

[Configuring Trust Behavior for the Device Type](#)

## Wireless QoS Mobility

Wireless QoS mobility enables you to configure QoS policies so that the network provides the same service anywhere in the network. A wireless client can roam from one location to another and as a result the client can get associated to different access points associated with a different device. Wireless client roaming can be classified into two types:

- Intra-device roaming
- Inter-device roaming



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**Note** The client policies must be available on all of the devices in the mobility group. The same SSID and port policy must be applied to all devices in the mobility group so that the clients get consistent treatment.

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## Inter-Device Roaming

When a client roams from one location to another, the client can get associated to access points either associated to the same device (anchor device) or a different device (foreign device). Inter-device roaming refers to the scenario where the client gets associated to an access point that is not associated to the same device before the client roamed. The host device is now foreign to the device to which the client was initially anchored.

In the case of inter-device roaming, the client QoS policy is always executed on the foreign controller. When a client roams from anchor device to foreign device, the QoS policy is uninstalled on the anchor device and installed on the foreign device. In the mobility handoff message, the anchor device passes the name of the policy to the foreign device. The foreign device should have a policy with the same name configured for the QoS policy to be applied correctly.

In the case of inter-device roaming, all of the QoS policies are moved from the anchor device to the foreign device. While the QoS policies are in transition from the anchor device to the foreign device, the traffic on the foreign device is provided the default treatment. This is comparable to a new policy installation on the client target.



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**Note** If the foreign device is not configured with the user-defined physical port policy, the default port policy is applicable to all traffic is routed through the NRT queue, except the control traffic which goes through RT1 queue. The network administrator must configure the same physical port policy on both the anchor and foreign devices symmetrically.

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During inter-device roaming, client and SSID policy statistics are collected only for the duration that the client is associated with the foreign device. Cumulative statistics for the whole roaming (anchor device and foreign device) are not collected.

## Intra-Device Roaming

With intra-device roaming, the client gets associated to an access point that is associated to the same device before the client roamed, but this association to the device occurs through a different access point.



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**Note** QoS policies remain intact in the case of intra-device roaming.

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## Precious Metal Policies for Wireless QoS

Wireless QoS is backward compatible with the precious metal policies offered by the unified wireless controller platforms. The precious metal policies are system-defined policies that are available on the controller.

The following policies are available:

- Platinum—Used for VoIP clients.
- Gold—Used for video clients.
- Silver— Used for traffic that can be considered best-effort.
- Bronze—Used for NRT traffic.

These policies (also known as profiles) can be applied to a WLAN based on the traffic. We recommend the configuration using the Cisco IOS MQC configuration. The policies are available in the system based on the precious metal policy required. You can configure precious metal policies only for SSID ingress and egress policies.

Based on the policies applied, the 802.1p, 802.11e (WMM), and DSCP fields in the packets are affected. These values are preconfigured and installed when the device is booted.



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**Note** Unlike the precious metal policies that were applicable in the Cisco Unified Wireless controllers, the attributes `rt-average-rate`, `nrt-average-rate`, and `peak rates` are not applicable for the precious metal policies configured on this device platform.

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### Related Topics

[Configuring Precious Metal Policies \(CLI\)](#), on page 1410

## Standard QoS Default Settings

### Default Wired QoS Configuration

There are two queues configured by default on each wired interface on the device. All control traffic traverses and is processed through queue 0. All other traffic traverses and is processed through queue 1.

## DSCP Maps

### Default CoS-to-DSCP Map

When DSCP transparency mode is disabled, the DSCP values are derived from CoS as per the following table. If these values are not appropriate for your network, you need to modify them.

**Note** The DSCP transparency mode is disabled by default. If it is enabled (**no mls qos rewrite ip dscp** interface configuration command), DSCP rewrite will not happen.

**Table 98: Default CoS-to-DSCP Map**

CoS Value	DSCP Value
0	0
1	8
2	16
3	24
4	32
5	40
6	48
7	56

### Default IP-Precedence-to-DSCP Map

You use the IP-precedence-to-DSCP map to map IP precedence values in incoming packets to a DSCP value that QoS uses internally to represent the priority of the traffic. The following table shows the default IP-precedence-to-DSCP map. If these values are not appropriate for your network, you need to modify them.

**Table 99: Default IP-Precedence-to-DSCP Map**

IP Precedence Value	DSCP Value
0	0
1	8
2	16
3	24
4	32
5	40
6	48
7	56

### Default DSCP-to-CoS Map

You use the DSCP-to-CoS map to generate a CoS value, which is used to select one of the four egress queues. The following table shows the default DSCP-to-CoS map. If these values are not appropriate for your network, you need to modify them.

**Table 100: Default DSCP-to-CoS Map**

DSCP Value	CoS Value
0–7	0
8–15	1
16–23	2
24–31	3
32–39	4
40–47	5
48–55	6
56–63	7

## Default Wireless QoS Configuration

The ports on the switch do not distinguish between wired or wireless physical ports. Depending on the kind of device associated to the switch, the policies are applied. For example, when an access point is connected to a switch port, the switch detects it as a wireless device and applies the default hierarchical policy which is in the format of a parent-child policy. This policy is an hierarchical policy. The parent policy cannot be modified but the child policy (port-child policy) can be modified to suite the QoS configuration. The switch is preconfigured with a default class map and a policy map.

## Guidelines for QoS Policies

Follow these guidelines to prevent clients from getting excluded due to malformed QoS policies:

- When a new QoS policy is added to the device, a QoS policy with the same name should be added to other device within the same roam or mobility domain.
- When a device is loaded with a software image of a later release, the new policy formats are supported. If you have upgraded the software image from an earlier release to a later release, you should save the configuration separately. When an earlier release image is loaded, some QoS policies might show as not supported, and you should restore those QoS policies to supported policy formats.

## Restrictions for QoS on Wired Targets

A target is an entity where a policy is applied. You can apply a policy to either a wired or wireless target. A wired target can be either a port or VLAN. A wireless target can be either a port, radio, SSID, or client. Only

port, SSID, and client policies are user configurable. Radio polices are not user configurable. Wireless QoS policies for port, radio, SSID, and client are applied in the downstream direction, and for upstream only SSID and client targets are supported. Downstream indicates that traffic is flowing from the device to the wireless client. Upstream indicates that traffic is flowing from wireless client to the device.

The following are restrictions for applying QoS features on the device for the wired target:

- A maximum of 8 queuing classes are supported on the device port for the wired target.
- A maximum of 63 policers are supported per policy on the wired port for the wired target.
- In Cisco IOS XE Release 3.7.5E and later releases, by default all downlink ports are allocated 1 GB port buffer, even though the downlink port size is 10 GB. Prior to this change, all 1 GB downlink ports had 1 GB buffer and 10 GB downlink ports had 10 GB buffer.
- A maximum of 1599 policy-maps can be created.
- No more than two levels are supported in a QoS hierarchy.
- In a hierarchical policy, overlapping actions between parent and child are not allowed, except when a policy has the port shaper in the parent and queueing features in the child policy.
- A QoS policy cannot be attached to any EtherChannel interface.
- Policing in both the parent and child is not supported in a QoS hierarchy.
- Marking in both the parent and child is not supported in a QoS hierarchy.
- A mixture of queue limit and queue buffer in the same policy is not supported.




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**Note** The queue-limit percent is not supported on the device because the **queue-buffer** command handles this functionality. Queue limit is only supported with the DSCP and CoS extensions.

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- With shaping, there is an IPG overhead of 20Bytes for every packet that is accounted internally in the hardware. Shaping accuracy will be effected by this, specially for packets of small size.
- The classification sequence for all wired queuing-based policies should be the same across all wired upstream ports (10-Gigabit Ethernet), and the same for all downstream wired ports (1-Gigabit Ethernet).
- Empty classes are not supported.
- Class-maps with empty actions are not supported. If there are two policies with the same order of class-maps and if there are class-maps with no action in one of the policies, there may be traffic drops. As a workaround, allocate minimal bandwidth for all the classes in PRIORITY\_QUEUE.
- A maximum of 256 classes are supported per policy on the wired port for the wired target.
- The actions under a policer within a policy map have the following restrictions:
  - The conform action must be transmit.
  - The exceed/violate action for markdown type can only be cos2cos, prec2prec, dscp2dscp.
  - The markdown types must be the same within a policy.

- A port-level input marking policy takes precedence over an SVI policy; however, if no port policy is configured, the SVI policy takes precedence. For a port policy to take precedence, define a port-level policy; so that the SVI policy is overwritten.
- Classification counters have the following specific restrictions:
  - Classification counters count packets instead of bytes.
  - Filter-based classification counters are not supported
  - Only QoS configurations with marking or policing trigger the classification counter.
  - The classification counter is not port based. This means that the classification counter aggregates all packets belonging to the same class of the same policy which attach to different interfaces.
  - As long as there is policing or marking action in the policy, the class-default will have classification counters.
  - When there are multiple match statements in a class, then the classification counter only shows the traffic counter for one of the match statements.
- Table maps have the following specific restrictions:
  - Only one table map for policing exceeding the markdown and one table map for policing violating the markdown per direction per target is supported.
  - Table maps must be configured under the class-default; table maps are unsupported for a user-defined class.
- Hierarchical policies are required for the following:
  - Port-shapers
  - Aggregate policers
  - PV policy
  - Parent shaping and child marking/policing
- In a HQoS policy with parent shaping and child policy having priority level queuing and priority level policing, the statistics for policing are not updated. Only QoS shaper statistics are updated. To view the QoS shaper statistics, use the **show policy-map interface** command in global configuration mode.
- For ports with wired targets, these are the only supported hierarchical policies:
  - Police chaining in the same policy is unsupported, except for wireless client.
  - Hierarchical queuing is unsupported in the same policy (port shaper is the exception).
  - In a parent class, all filters must have the same type. The child filter type must match the parent filter type with the following exceptions:
    - If the parent class is configured to match IP, then the child class can be configured to match the ACL.
    - If the parent class is configured to match CoS, then the child class can be configured to match the ACL.

- The **trust device** *device\_type* command available in interface configuration mode is a stand-alone command on the device. When using this command in an AutoQoS configuration, if the connected peer device is not a corresponding device (defined as a device matching your trust policy), both CoS and DSCP values are set to "0" and any input policy will not take effect. If the connected peer device is a corresponding device, input policy will take effect.

The following are restrictions for applying QoS features on the VLAN to the wired target:

- For a flat or nonhierarchical policy, only marking or a table map is supported.

The following are restrictions and considerations for applying QoS features on EtherChannel and channel member interfaces:

- QoS is not supported on an EtherChannel interface.
- QoS is supported on EtherChannel member interfaces in both ingress and egression directions. All EtherChannel members must have the same QoS policy applied. If the QoS policy is not the same, each individual policy on the different link acts independently.
- On attaching a service policy to channel members, the following warning message appears to remind the user to make sure the same policy is attached to all ports in the EtherChannel: ' Warning: add service policy will cause inconsistency with port xxx in ether channel xxx. '.
- Auto QoS is not supported on EtherChannel members.



#### Note

On attaching a service policy to an EtherChannel, the following message appears on the console: ' Warning: add service policy will cause inconsistency with port xxx in ether channel xxx. '. This warning message should be expected. This warning message is a reminder to attach the same policy to other ports in the same EtherChannel. The same message will be seen during boot up. This message does not mean there is a discrepancy between the EtherChannel member ports.

#### Related Topics

[Restrictions for QoS on Wireless Targets](#), on page 1362

[Prerequisites for Quality of Service](#), on page 1322

[QoS Overview](#), on page 1324

[QoS Implementation](#), on page 1334

## Restrictions for QoS on Wireless Targets

### General Restrictions

A target is an entity where a policy is applied. You can apply a policy to either a wired or wireless target. A wired target can be either a port or VLAN. A wireless target can be either a port, radio, SSID, or client. Only port, SSID, and client policies are user configurable. Radio policies are not user configurable. Wireless QoS policies for port, radio, SSID, and client are applied in the downstream direction, and for upstream only SSID and client targets are supported. Downstream indicates that traffic is flowing from the device to the wireless client. Upstream indicates that traffic is flowing from wireless client to the device.





**Note** Auto QOS SRND is enabled by default on the Cisco Catalyst 4500E Supervisor Engine 8-E. When AP is connected, egress QoS policy is automatically applied on the AP connected ports and the QoS policy is removed when the AP is disconnected. This policy classification is applied through DSCP, so the drop threshold can be configured for voice and CAPWAP control packets. All other traffic goes to different queues. If you prefer to have a different QoS policy to prioritize different class of traffic, you can configure it using the 'no auto qos srnd4' command. This will remove the Auto QOS SRND4 policies attached to AP connected port and BB-DC inter-link port, and a default policy to protect CAPWAP control and voice traffic will be attached to BB-DC inter-link port.

- Only port, SSID, and client (using AAA and Cisco IOS command-line interface) policies are user-configurable. Radio policies are set by the wireless control module and are not user-configurable.
- Port and radio policies are applicable only in the egress direction.
- SSID and client targets can be configured only with marking and policing policies.
- One policy per target per direction is supported.
- For the egress class-default SSID policy, you must configure the queue buffer ratio as 0 after you configure the average shape rate.
- Class maps in a policy map can have different types of filters. However, only one marking action (either table map, or set dscp, or set cos) is supported in a map in egress direction.
- For hierarchical client and SSID ingress policies, you cannot configure marking in both the parent and child policies. You can only configure marking either in the parent or child policy.
- You cannot configure multiple set actions in the same class.
- For both SSID and client ingress policies, supported set actions are only for DSCP, and CoS values.
- You cannot delete a group of WLANs or QoS policy.

### Wireless QoS Restrictions on Ports

The following are restrictions for applying QoS features on a wireless port target:

- All wireless ports have similar parent policy with one class-default and one action shape under class-default. Shape rates are dependent on the 802.11a/b/g/ac bands.
- You can create a maximum of four classes in a child policy by modifying the `port_child_policy`.
- If there are four classes in the `port_child_policy` at the port level, one must be a non-client-nrt class and one must be class-default.
- No two classes can have the same priority level. Only priority level 1 (for voice traffic and control traffic) and 2 (for video) are supported.
- Priority is not supported in the multicast NRT class (non-client-nrt class) and `class-default`.
- If four classes are configured, two of them have to be priority classes. If only three classes are configured, at least one of them should be a priority class. If three classes are configured and there is no non-client-nrt class, both priority levels must be present.
- Only match DSCP is supported.
- The port policy applied by the wireless control module cannot be removed using the CLI.

- Both priority rate and police CIR (using MQC) in the same class is unsupported.
- Queue limit (which is used to configure Weighted Tail Drop) is unsupported.

### Wireless QoS Restrictions on SSID

The following are restrictions for applying QoS features on SSID:

- One table map is supported at the ingress policy.
- Table maps are supported for the parent class-default only. Up to two table maps are supported in the egress direction and three table-maps can be configured when a QoS group is involved.




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**Note** Table-maps are not supported at the client targets.

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- If a wireless port has a default policy with only two queues (one for multicast-NRT, one for class-default), the policy at SSID level cannot have voice and video class in the egress direction.
- Policing without priority is not supported in the egress direction.
- Priority configuration at the SSID level is used only to configure the RT1 and RT2 policers (AFD for policer). Priority configuration does not include the shape rate. Therefore, priority is restricted for SSID policies without police.
- If **set** is not enabled in class-default, the classification at the SSID for voice or video must be a subset of the classification for the voice or video class at the port level.
- The mapping in the DSCP2DSCP and COS2COS table should be based on the classification function for the voice and video classes in the port level policy.
- No action is allowed under the class-default of a child policy.
- For SSID ingress policies, only UP and DSCP filters (match criteria) are supported. ACL and protocol match criteria are not supported.
- For a flat policy (non hierarchical), in the ingress direction, the policy configuration must be a set (table map) or policing or both.

### Wireless QoS Restrictions on Clients

The following are restrictions for applying QoS policies on client targets:

- The default client policy is enabled only on WMM clients that are ACM-enabled.
- Queuing is not supported.
- Attaching, removing, or modifying client policies on a WLAN in the enabled state is not supported. You must shut down the WLAN to apply, remove, or modify a policy.
- Table-map configuration is not supported for client targets.
- Policing and set configured together in class-default is blocked in egress direction:

```
policy-map foo
class class-default
```

```
police X
set dscp Y
```

- Child policy is not supported under class-default if the parent policy contains other user-defined class maps in it.
- For flat egress client policy, policing in class-default and marking action in other classes are not supported.
- Only set marking actions are supported in the client policies.
- For client ingress policies, only ACL, UP, DSCP, and protocol filters (match criteria) are supported.
- All the filters in classes in a policy map for client policy must have the same attributes. Filters matching on protocol-specific attributes such as IPv4 or IPv6 addresses are considered as different attribute sets.
- For filters matching on ACLs, all ACEs (Access Control Entry) in the access list should have the same type and number of attributes.
- In client egress policies, all filters in the policy-map must match on the same marking attribute for filters matching on marking attributes. For example, If filter matches on DSCP, then all filters in the policy must match on DSCP.
- ACL matching on port ranges and subnet are only supported in ingress direction.

#### Related Topics

[Port Policies](#), on page 1329

[Port Policy Format](#), on page 1329

[Radio Policies](#), on page 1331

[Restrictions for QoS on Wired Targets](#), on page 1359

[Prerequisites for Quality of Service](#), on page 1322

[QoS Overview](#), on page 1324

[QoS Implementation](#), on page 1334

# How to Configure QoS

## Configuring Class, Policy, and Table Maps

### Creating a Traffic Class (CLI)

To create a traffic class containing match criteria, use the **class-map** command to specify the traffic class name, and then use the following **match** commands in class-map configuration mode, as needed.

#### Before you begin

All match commands specified in this configuration task are considered optional, but you must configure at least one match criterion for a class.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<b>class-map</b> <i>class-map name</i> { <b>match-any</b>   <b>match-all</b> } <b>Example:</b> <pre>Device (config) # class-map test_1000 Device (config-cmap) #</pre>	Enters class map configuration mode. <ul style="list-style-type: none"> <li>Creates a class map to be used for matching packets to the class whose name you specify.</li> <li><b>match-any:</b> Any one of the match criteria must be met for traffic entering the traffic class to be classified as part of it.</li> <li><b>match-all:</b> All of the match criteria must be met for traffic entering the traffic class to be classified as part of the traffic class.</li> </ul> <p><b>Note</b> This is the default. If <b>match-any</b> or <b>match-all</b> is not explicitly defined, <b>match-all</b> is chosen by default.</p>
<b>Step 3</b>	<b>match access-group</b> { <i>index number</i>   <i>name</i> } <b>Example:</b> <pre>Device (config-cmap) # match access-group 100 Device (config-cmap) #</pre>	The following parameters are available for this command: <ul style="list-style-type: none"> <li>access-group</li> <li>class-map</li> <li>cos</li> <li>dscp</li> <li>ip</li> <li>non-client-nrt</li> <li>precedence</li> <li>qos-group</li> <li>vlan</li> <li>wlan user priority</li> </ul> (Optional) For this example, enter the access-group ID: <ul style="list-style-type: none"> <li>Access list index (value from 1 to 2799)</li> <li>Named access list</li> </ul>

	Command or Action	Purpose
<b>Step 4</b>	<b>match class-map</b> <i>class-map name</i> <b>Example:</b> <pre>Device(config-cmap)# <b>match class-map</b> <b>test_2000</b> Device(config-cmap)#</pre>	(Optional) Matches to another class-map name.
<b>Step 5</b>	<b>match cos</b> <i>cos value</i> <b>Example:</b> <pre>Device(config-cmap)# <b>match cos 2 3 4 5</b> Device(config-cmap)#</pre>	(Optional) Matches IEEE 802.1Q or ISL class of service (user) priority values. <ul style="list-style-type: none"> <li>• Enters up to 4 CoS values separated by spaces (0 to 7).</li> </ul>
<b>Step 6</b>	<b>match dscp</b> <i>dscp value</i> <b>Example:</b> <pre>Device(config-cmap)# <b>match dscp af11</b> <b>af12</b> Device(config-cmap)#</pre>	(Optional) Matches the DSCP values in IPv4 and IPv6 packets.
<b>Step 7</b>	<b>match ip</b> { <b>dscp</b> <i>dscp value</i>   <b>precedence</b> <i>precedence value</i> } <b>Example:</b> <pre>Device(config-cmap)# <b>match ip dscp af11</b> <b>af12</b> Device(config-cmap)#</pre>	(Optional) Matches IP values including the following: <ul style="list-style-type: none"> <li>• <b>dscp</b>—Matches IP DSCP (DiffServ codepoints).</li> <li>• <b>precedence</b>—Matches IP precedence (0 to 7).</li> </ul> <p><b>Note</b> Since CPU generated packets are not marked at egress, the packet will not match the configured class-map.</p>
<b>Step 8</b>	<b>match non-client-nrt</b> <b>Example:</b> <pre>Device(config-cmap)# <b>match</b> <b>non-client-nrt</b> Device(config-cmap)#</pre>	(Optional) Matches non-client NRT (Non-Real-Time). <p><b>Note</b> This match is applicable only for policies on a wireless port. It carries all the multi-destination and AP (non-client) bound traffic.</p>
<b>Step 9</b>	<b>match qos-group</b> <i>qos group value</i> <b>Example:</b> <pre>Device(config-cmap)# <b>match qos-group 10</b> Device(config-cmap)#</pre>	(Optional) Matches QoS group value (from 0 to 31).

	Command or Action	Purpose
<b>Step 10</b>	<b>match vlan</b> <i>vlan value</i> <b>Example:</b> <pre>Device(config-cmap) # <b>match vlan 210</b> Device(config-cmap) #</pre>	(Optional) Matches a VLAN ID (from 1 to 4095).
<b>Step 11</b>	<b>match wlan user-priority</b> <i>wlan value</i> <b>Example:</b> <pre>Device(config-cmap) # <b>match wlan user priority 7</b> Device(config-cmap) #</pre>	(Optional) Matches 802.11e specific values. Enter the user priority 802.11e user priority (0 to 7).
<b>Step 12</b>	<b>end</b> <b>Example:</b> <pre>Device(config-cmap) # <b>end</b></pre>	Saves the configuration changes.

**What to do next**

Configure the policy map.

**Related Topics**

[Class Maps](#), on page 1340

[Examples: Classification by Access Control Lists](#), on page 1414

**Creating a Traffic Policy (CLI)**

To create a traffic policy, use the **policy-map** global configuration command to specify the traffic policy name.

The traffic class is associated with the traffic policy when the **class** command is used. The **class** command must be entered after you enter the policy map configuration mode. After entering the **class** command, the device is automatically in policy map class configuration mode, which is where the QoS policies for the traffic policy are defined.

The following policy map class-actions are supported:

- **admit**—Admits the request for Call Admission Control (CAC).
- **bandwidth**—Bandwidth configuration options.
- **exit**—Exits from the QoS class action configuration mode.
- **no**—Negates or sets default values for the command.
- **police**—Policer configuration options.
- **priority**—Strict scheduling priority configuration options for this class.

- queue-buffers—Queue buffer configuration options.
- queue-limit—Queue maximum threshold for Weighted Tail Drop (WTD) configuration options.
- service-policy—Configures the QoS service policy.
- set—Sets QoS values using the following options:
  - CoS values
  - DSCP values
  - Precedence values
  - QoS group values
  - WLAN values
- shape—Traffic-shaping configuration options.

### Before you begin

You should have first created a class map.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>policy-map</b> <i>policy-map name</i> <b>Example:</b> Device(config)# <b>policy-map test_2000</b> Device(config-pmap)#	Enters policy map configuration mode. Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.
<b>Step 3</b>	<b>class</b> { <i>class-name</i>   <b>class-default</b> } <b>Example:</b> Device(config-pmap)# <b>class test_1000</b> Device(config-pmap-c)#	Specifies the name of the class whose policy you want to create or change. You can also create a system default class for unclassified packets.
<b>Step 4</b>	<b>admit</b> <b>Example:</b> Device(config-pmap-c)# <b>admit cac</b> <b>wmm-tspec</b> Device(config-pmap-c)#	(Optional) Admits the request for Call Admission Control (CAC). For a more detailed example of this command and its usage, see the section Configuring Call Admission Control.

	Command or Action	Purpose
		<b>Note</b> This command only configures CAC for wireless QoS.
<b>Step 5</b>	<b>bandwidth</b> { <i>kb/s kb/s value</i>   <b>percent percentage</b>   <b>remaining</b> { <i>percent</i>   <i>ratio</i> } } <b>Example:</b> <pre>Device(config-pmap-c)# bandwidth 50 Device(config-pmap-c)#</pre>	(Optional) Sets the bandwidth using one of the following: <ul style="list-style-type: none"> <li>• <b>kb/s</b>—Kilobits per second, enter a value between 20000 and 10000000 for Kb/s.</li> <li>• <b>percent</b>—Enter the percentage of the total bandwidth to be used for this policy map.</li> <li>• <b>remaining</b>—Enter the percentage ratio of the remaining bandwidth.</li> </ul> For a more detailed example of this command and its usage, see <a href="#">Configuring Bandwidth (CLI)</a> , on page 1397.
<b>Step 6</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-pmap-c)# exit Device(config-pmap-c)#</pre>	(Optional) Exits from QoS class action configuration mode.
<b>Step 7</b>	<b>no</b> <b>Example:</b> <pre>Device(config-pmap-c)# no Device(config-pmap-c)#</pre>	(Optional) Negates the command.
<b>Step 8</b>	<b>police</b> { <i>target_bit_rate</i>   <b>cir</b>   <b>rate</b> } <b>Example:</b> <pre>Device(config-pmap-c)# police 100000 Device(config-pmap-c)#</pre>	(Optional) Configures the policer: <ul style="list-style-type: none"> <li>• <b>target_bit_rate</b>—Enter the bit rate per second, enter a value between 8000 and 10000000000.</li> <li>• <b>cir</b>—Committed Information Rate</li> <li>• <b>rate</b>—Specify police rate, PCR for hierarchical policies or SCR for single-level ATM 4.0 policer policies.</li> </ul> For a more detailed example of this command and its usage, see <a href="#">Configuring Police (CLI)</a> , on page 1399.
<b>Step 9</b>	<b>priority</b> { <i>kb/s</i>   <b>level level value</b>   <b>percent percentage value</b> }	(Optional) Sets the strict scheduling priority for this class. Command options include:



	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config-pmap-c) # <b>priority percent</b> <b>50</b> Device(config-pmap-c) #</pre>	<ul style="list-style-type: none"> <li>• <b>kb/s</b>—Kilobits per second, enter a value between 1 and 2000000.</li> <li>• <b>level</b>—Establishes a multi-level priority queue. Enter a value (1 or 2).</li> <li>• <b>percent</b>—Enter a percent of the total bandwidth for this priority.</li> </ul> <p>For a more detailed example of this command and its usage, see <a href="#">Configuring Priority (CLI)</a>, on page 1402.</p>
<b>Step 10</b>	<p><b>queue-buffers ratio ratio limit</b></p> <p><b>Example:</b></p> <pre>Device(config-pmap-c) # <b>queue-buffers</b> <b>ratio 10</b> Device(config-pmap-c) #</pre>	<p>(Optional) Configures the queue buffer for the class. Enter the queue buffers ratio limit (0 to 100).</p> <p>For a more detailed example of this command and its usage, see <a href="#">Configuring Queue Buffers (CLI)</a>, on page 1404.</p>
<b>Step 11</b>	<p><b>queue-limit {packets   cos   dscp   percent}</b></p> <p><b>Example:</b></p> <pre>Device(config-pmap-c) # <b>queue-limit cos</b> <b>7 percent 50</b> Device(config-pmap-c) #</pre>	<p>(Optional) Specifies the queue maximum threshold for the tail drop:</p> <ul style="list-style-type: none"> <li>• <b>packets</b>—Packets by default, enter a value between 1 to 2000000.</li> <li>• <b>cos</b>—Enter the parameters for each COS value.</li> <li>• <b>dscp</b>—Enter the parameters for each DSCP value.</li> <li>• <b>percent</b>—Enter the percentage for the threshold.</li> </ul> <p>For a more detailed example of this command and its usage, see <a href="#">Configuring Queue Limits (CLI)</a>, on page 1406.</p>
<b>Step 12</b>	<p><b>service-policy policy-map name</b></p> <p><b>Example:</b></p> <pre>Device(config-pmap-c) # <b>service-policy</b> <b>test_2000</b> Device(config-pmap-c) #</pre>	<p>(Optional) Configures the QoS service policy.</p>
<b>Step 13</b>	<p><b>set {cos   dscp   ip   precedence   qos-group   wlan}</b></p> <p><b>Example:</b></p> <pre>Device(config-pmap-c) # <b>set cos 7</b></pre>	<p>(Optional) Sets the QoS values. Possible QoS configuration values include:</p> <ul style="list-style-type: none"> <li>• <b>cos</b>—Sets the IEEE 802.1Q/ISL class of service/user priority.</li> </ul>

	Command or Action	Purpose
	Device (config-pmap-c) #	<ul style="list-style-type: none"> <li>• <b>dscp</b>—Sets DSCP in IP(v4) and IPv6 packets.</li> <li>• <b>ip</b>—Sets IP specific values.</li> <li>• <b>precedence</b>—Sets precedence in IP(v4) and IPv6 packet.</li> <li>• <b>qos-group</b>—Sets the QoS Group.</li> <li>• <b>wlan</b>—Sets the WLAN user-priority.</li> </ul>
<b>Step 14</b>	<b>shape average</b> { <i>target_bit_rate</i>   <b>percent</b> } <b>Example:</b> <pre>Device (config-pmap-c) #shape average percent 50 Device (config-pmap-c) #</pre>	(Optional) Sets the traffic shaping. Command parameters include: <ul style="list-style-type: none"> <li>• <i>target_bit_rate</i>—Target bit rate.</li> <li>• <b>percent</b>—Percentage of interface bandwidth for Committed Information Rate.</li> </ul> For a more detailed example of this command and its usage, see <a href="#">Configuring Shaping (CLI)</a> , on page 1409.
<b>Step 15</b>	<b>end</b> <b>Example:</b> <pre>Device (config-pmap-c) #end Device (config-pmap-c) #</pre>	Saves the configuration changes.

**What to do next**

Configure the interface.

**Related Topics**

[Policy Maps](#), on page 1341

**Configuring Client Policies**

You can configure client policies using one of the following methods:

Method	Topic/ Details
Default client policies	<p>The wireless control module of the applies the default client policies when admission control (ACM) is enabled for WMM clients. When ACM is disabled, there is no default client policy.</p> <p>The default policies are:</p> <ul style="list-style-type: none"> <li>• Ingress—cldeffromWMM</li> <li>• Egress—cldeftoWMM</li> </ul> <p>You can verify if ACM is enabled by using the <b>show ap dot11 {5ghz   24ghz}</b> command. To enable ACM, use the <b>ap dot11 {5ghz   24ghz} cac voice acm</b> command.</p>
Apply the client policy on the WLAN using the CLI.	<a href="#">Applying an SSID or Client Policy on a WLAN (CLI), on page 1380</a>
Apply the QoS attributes policy using a local profiling policy using the CLI.	<a href="#">Applying a Local Policy for a Device on a WLAN (CLI), on page 1098</a>
Apply policy map through a AAA server (ACS/ISE)	<p><i>Cisco Identity Services Engine User Guide</i></p> <p><i>Cisco Secure Access Control System User Guide</i></p>

## Configuring Class-Based Packet Marking (CLI)

This procedure explains how to configure the following class-based packet marking features on your device:

- CoS value
- DSCP value
- IP value
- Precedence value
- QoS group value
- WLAN value

### Before you begin

You should have created a class map and a policy map before beginning this procedure.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 2</b>	<p><code>policy-map policy name</code></p> <p><b>Example:</b></p> <pre>Device(config)# policy-map policy1 Device(config-pmap)#</pre>	<p>Enters policy map configuration mode.</p> <p>Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.</p>
<b>Step 3</b>	<p><code>class class name</code></p> <p><b>Example:</b></p> <pre>Device(config-pmap)# class class1 Device(config-pmap-c)#</pre>	<p>Enters policy class map configuration mode. Specifies the name of the class whose policy you want to create or change.</p> <p>Command options for policy class map configuration mode include the following:</p> <ul style="list-style-type: none"> <li>• <b>admit</b>—Admits the request for Call Admission Control (CAC).</li> <li>• <b>bandwidth</b>—Bandwidth configuration options.</li> <li>• <b>exit</b>—Exits from the QoS class action configuration mode.</li> <li>• <b>no</b>—Negates or sets default values for the command.</li> <li>• <b>police</b>—Policer configuration options.</li> <li>• <b>priority</b>—Strict scheduling priority configuration options for this class.</li> <li>• <b>queue-buffers</b>—Queue buffer configuration options.</li> <li>• <b>queue-limit</b>—Queue maximum threshold for Weighted Tail Drop (WTD) configuration options.</li> <li>• <b>service-policy</b>—Configures the QoS service policy.</li> <li>• <b>set</b>—Sets QoS values using the following options: <ul style="list-style-type: none"> <li>• CoS values</li> <li>• DSCP values</li> <li>• Precedence values</li> <li>• QoS group values</li> <li>• WLAN values</li> </ul> </li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>shape</b>—Traffic-shaping configuration options.</li> </ul> <p><b>Note</b> This procedure describes the available configurations using <b>set</b> command options. The other command options (<b>admit</b>, <b>bandwidth</b>, etc.) are described in other sections of this guide. Although this task lists all of the possible <b>set</b> commands, only one <b>set</b> command is supported per class.</p>
<b>Step 4</b>	<p><b>set cos</b> {<i>cos value</i>   <b>cos table</b> <i>table-map name</i>   <b>dscp table</b> <i>table-map name</i>   <b>precedence table</b> <i>table-map name</i>   <b>qos-group table</b> <i>table-map name</i>   <b>wlan user-priority table</b> <i>table-map name</i>}</p> <p><b>Example:</b></p> <pre>Device(config-pmap)# set cos 5 Device(config-pmap)#</pre>	<p>(Optional) Sets the specific IEEE 802.1Q Layer 2 CoS value of an outgoing packet. Values are from 0 to 7.</p> <p>You can also set the following values using the <b>set cos</b> command:</p> <ul style="list-style-type: none"> <li>• <b>cos table</b>—Sets the CoS value based on a table map.</li> <li>• <b>dscp table</b>—Sets the code point value based on a table map.</li> <li>• <b>precedence table</b>—Sets the code point value based on a table map.</li> <li>• <b>qos-group table</b>—Sets the CoS value from QoS group based on a table map.</li> <li>• <b>wlan user-priority table</b>—Sets the CoS value from the WLAN user priority based on a table map.</li> </ul>
<b>Step 5</b>	<p><b>set dscp</b> {<i>dscp value</i>   <b>default</b>   <b>dscp table</b> <i>table-map name</i>   <b>ef</b>   <b>precedence table</b> <i>table-map name</i>   <b>qos-group table</b> <i>table-map name</i>   <b>wlan user-priority table</b> <i>table-map name</i>}</p> <p><b>Example:</b></p> <pre>Device(config-pmap)# set dscp af11 Device(config-pmap)#</pre>	<p>(Optional) Sets the DSCP value.</p> <p>In addition to setting specific DSCP values, you can also set the following using the <b>set dscp</b> command:</p> <ul style="list-style-type: none"> <li>• <b>default</b>—Matches packets with default DSCP value (000000).</li> <li>• <b>dscp table</b>—Sets the packet DSCP value from DSCP based on a table map.</li> <li>• <b>ef</b>—Matches packets with EF DSCP value (101110).</li> <li>• <b>precedence table</b>—Sets the packet DSCP value from precedence based on a table map.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>qos-group table</b>—Sets the packet DSCP value from a QoS group based upon a table map.</li> <li>• <b>wlan user-priority table</b>—Sets the packet DSCP value based upon a WLAN user-priority based upon a table map.</li> </ul>
<b>Step 6</b>	<p><b>set ip {dscp   precedence}</b></p> <p><b>Example:</b></p> <pre>Device(config-pmap)# set ip dscp c3 Device(config-pmap)#</pre>	<p>(Optional) Sets IP specific values. These values are either IP DSCP or IP precedence values.</p> <p>You can set the following values using the <b>set ip dscp</b> command:</p> <ul style="list-style-type: none"> <li>• <i>dscp value</i>—Sets a specific DSCP value.</li> <li>• <b>default</b>—Matches packets with default DSCP value (000000).</li> <li>• <b>dscp table</b>—Sets the packet DSCP value from DSCP based on a table map.</li> <li>• <b>ef</b>—Matches packets with EF DSCP value (101110).</li> <li>• <b>precedence table</b>—Sets the packet DSCP value from precedence based on a table map.</li> <li>• <b>qos-group table</b>—Sets the packet DSCP value from a QoS group based upon a table map.</li> <li>• <b>wlan user-priority table</b>—Sets the packet DSCP value based upon a WLAN user-priority based upon a table map.</li> </ul> <p>You can set the following values using the <b>set ip precedence</b> command:</p> <ul style="list-style-type: none"> <li>• <i>precedence value</i>—Sets the precedence value (from 0 to 7) .</li> <li>• <b>cos table</b>—Sets the packet precedence value from Layer 2 CoS based on a table map.</li> <li>• <b>dscp table</b>—Sets the packet precedence from DSCP value based on a table map.</li> <li>• <b>precedence table</b>—Sets the precedence value from precedence based on a table map</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>qos-group table</b>—Sets the precedence value from a QoS group based upon a table map.</li> </ul>
<b>Step 7</b>	<p><b>set precedence</b> {<i>precedence value</i>   <b>cos table</b> <i>table-map name</i>   <b>dscp table</b> <i>table-map name</i>   <b>precedence table</b> <i>table-map name</i>   <b>qos-group table</b> <i>table-map name</i>}</p> <p><b>Example:</b></p> <pre>Device(config-pmap)# set precedence 5 Device(config-pmap)#</pre>	<p>(Optional) Sets precedence values in IPv4 and IPv6 packets.</p> <p>You can set the following values using the <b>set precedence</b> command:</p> <ul style="list-style-type: none"> <li>• <i>precedence value</i>—Sets the precedence value (from 0 to 7).</li> <li>• <b>cos table</b>—Sets the packet precedence value from Layer 2 CoS on a table map.</li> <li>• <b>dscp table</b>—Sets the packet precedence from DSCP value on a table map.</li> <li>• <b>precedence table</b>—Sets the precedence value from precedence based on a table map.</li> <li>• <b>qos-group table</b>—Sets the precedence value from a QoS group based upon a table map.</li> </ul>
<b>Step 8</b>	<p><b>set qos-group</b> {<i>qos-group value</i>   <b>dscp table</b> <i>table-map name</i>   <b>precedence table</b> <i>table-map name</i>}</p> <p><b>Example:</b></p> <pre>Device(config-pmap)# set qos-group 10 Device(config-pmap)#</pre>	<p>(Optional) Sets QoS group values. You can set the following values using this command:</p> <ul style="list-style-type: none"> <li>• <i>qos-group value</i>—A number from 1 to 31.</li> <li>• <b>dscp table</b>—Sets the code point value from DSCP based on a table map.</li> <li>• <b>precedence table</b>—Sets the code point value from precedence based on a table map.</li> </ul>
<b>Step 9</b>	<p><b>set wlan user-priority</b> {<i>wlan user-priority value</i>   <b>cos table</b> <i>table-map name</i>   <b>dscp table</b> <i>table-map name</i>   <b>qos-group table</b> <i>table-map name</i>   <b>wlan table</b> <i>table-map name</i>}</p> <p><b>Example:</b></p> <pre>Device(config-pmap)# set wlan user-priority 1 Device(config-pmap)#</pre>	<p>(Optional) Sets the WLAN user priority value. You can set the following values using this command:</p> <ul style="list-style-type: none"> <li>• <i>wlan user-priority value</i>—A value between 0 to 7.</li> <li>• <b>cos table</b>—Sets the WLAN user priority value from CoS based on a table map.</li> <li>• <b>dscp table</b>—Sets the WLAN user priority value from DSCP based on a table map.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>qos-group table</b>—Sets the WLAN user priority value from QoS group based on a table map.</li> <li>• <b>wlan table</b>—Sets the WLAN user priority value from the WLAN user priority based on a table map.</li> </ul>
<b>Step 10</b>	<b>end</b> <b>Example:</b> <pre>Device(config-pmap)# end Device#</pre>	Saves configuration changes.
<b>Step 11</b>	<b>show policy-map</b> <b>Example:</b> <pre>Device# show policy-map</pre>	(Optional) Displays policy configuration information for all classes configured for all service policies.

**What to do next**

Attach the traffic policy to an interface using the **service-policy** command.

**Configuring Class Maps for Voice and Video (CLI)**

To configure class maps for voice and video traffic, follow these steps:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>class-map</b> <i>class-map-name</i> <b>Example:</b> <pre>Device(config)# class-map voice</pre>	Creates a class map.
<b>Step 2</b>	<b>match dscp</b> <i>dscp-value-for-voice</i> <b>Example:</b> <pre>Device(config-cmap)# match dscp 46</pre>	Matches the DSCP value in the IPv4 and IPv6 packets. Set this value to 46.
<b>Step 3</b>	<b>class-map</b> <i>class-map-name</i> <b>Example:</b> <pre>Device(config)# class-map video</pre>	Configures a class map.
<b>Step 4</b>	<b>match dscp</b> <i>dscp-value-for-video</i> <b>Example:</b> <pre>Device(config-cmap)# match dscp 34</pre>	Matches the DSCP value in the IPv4 and IPv6 packets. Set this value to 34.



## Attaching a Traffic Policy to an Interface (CLI)

After the traffic class and traffic policy are created, you must use the **service-policy** interface configuration command to attach a traffic policy to an interface, and to specify the direction in which the policy should be applied (either on packets coming into the interface or packets leaving the interface).

### Before you begin

A traffic class and traffic policy must be created before attaching a traffic policy to an interface.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface type</b> <b>Example:</b> Device(config)# <b>interface</b> <b>GigabitEthernet1/0/1</b> Device(config-if)#	Enters interface configuration mode and configures an interface. Command parameters for the interface configuration include: <ul style="list-style-type: none"> <li>• <b>Auto Template</b>— Auto-template interface</li> <li>• <b>Capwap</b>—CAPWAP tunnel interface</li> <li>• <b>GigabitEthernet</b>—Gigabit Ethernet IEEE 802</li> <li>• <b>GroupVI</b>—Group virtual interface</li> <li>• <b>Internal Interface</b>— Internal interface</li> <li>• <b>Loopback</b>—Loopback interface</li> <li>• <b>Null</b>—Null interface</li> <li>• <b>Port-channel</b>—Ethernet Channel of interface</li> <li>• <b>TenGigabitEthernet</b>—10-Gigabit Ethernet</li> <li>• <b>Tunnel</b>—Tunnel interface</li> <li>• <b>Vlan</b>—Catalyst VLANs</li> <li>• <b>Range</b>—Interface range</li> </ul>
<b>Step 3</b>	<b>service-policy {input policy-map   output policy-map }</b> <b>Example:</b>	Attaches a policy map to an input or output interface. This policy map is then used as the service policy for that interface.

	Command or Action	Purpose
	<pre>Device(config-if)# service-policy output policy_map_01 Device(config-if)#</pre>	In this example, the traffic policy evaluates all traffic leaving that interface.
<b>Step 4</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# end Device#</pre>	Saves configuration changes.
<b>Step 5</b>	<p><b>show policy map</b></p> <p><b>Example:</b></p> <pre>Device# show policy map</pre>	(Optional) Displays statistics for the policy on the specified interface.

**What to do next**

Proceed to attach any other traffic policy to an interface, and to specify the direction in which the policy should be applied.

**Related Topics**

[Policy Map on Physical Port](#), on page 1342

**Applying an SSID or Client Policy on a WLAN (CLI)****Before you begin**

You must have a service-policy map configured before applying it on an SSID.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<p><b>wlan <i>profile-name</i></b></p> <p><b>Example:</b></p> <pre>Device# wlan test4</pre>	Enters WLAN configuration submenu. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<p><b>service-policy [ input   output ] <i>policy-name</i></b></p> <p><b>Example:</b></p> <pre>Device(config-wlan)# service-policy input policy-map-ssid</pre>	<p>Applies the policy. The following options are available:</p> <ul style="list-style-type: none"> <li><b>input</b>— Assigns the policy map to WLAN ingress traffic.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>output</b>— Assigns the policy map to WLAN egress traffic.</li> </ul>
<b>Step 4</b>	<b>service-policy client [ input   output ]</b> <i>policy-name</i>  <b>Example:</b> <pre>Device(config-wlan)# service-policy client input policy-map-client</pre>	Applies the policy. The following options are available: <ul style="list-style-type: none"> <li>• <b>input</b>— Assigns the client policy for ingress direction on the WLAN.</li> <li>• <b>output</b>— Assigns the client policy for egress direction on the WLAN.</li> </ul>
<b>Step 5</b>	<b>end</b>  <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

**Related Topics**

[SSID Policies](#), on page 1331

[Supported QoS Features on Wireless Targets](#), on page 1327

[Examples: SSID Policy](#)

[Examples: Configuring Downstream SSID Policy](#), on page 1419

**Classifying, Policing, and Marking Traffic on Physical Ports by Using Policy Maps (CLI)**

You can configure a nonhierarchical policy map on a physical port that specifies which traffic class to act on. Actions supported are remarking and policing.

**Before you begin**

You should have already decided upon the classification, policing, and marking of your network traffic by policy maps prior to beginning this procedure.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<b>class-map { class-map name   match-any }</b>  <b>Example:</b> <pre>Device(config)# class-map ipclass1 Device(config-cmap)# exit Device(config)#</pre>	Enters class map configuration mode. <ul style="list-style-type: none"> <li>• Creates a class map to be used for matching packets to the class whose name you specify.</li> <li>• If you specify <b>match-any</b>, one of the match criteria must be met for traffic</li> </ul>

	Command or Action	Purpose
		entering the traffic class to be classified as part of the traffic class. This is the default.
<b>Step 3</b>	<p><b>match access-group</b> { <i>access list index</i>   <i>access list name</i> }</p> <p><b>Example:</b></p> <pre>Device (config-cmap) # match access-group 1000 Device (config-cmap) # exit Device (config) #</pre>	<p>Specifies the classification criteria to match to the class map. You can match on the following criteria:</p> <ul style="list-style-type: none"> <li>• <b>access-group</b>—Matches to access group.</li> <li>• <b>class-map</b>—Matches to another class map.</li> <li>• <b>cos</b>—Matches to a CoS value.</li> <li>• <b>dscp</b>—Matches to a DSCP value.</li> <li>• <b>ip</b>—Matches to a specific IP value.</li> <li>• <b>non-client-nrt</b>—Matches non-client NRT.</li> <li>• <b>precedence</b>—Matches precedence in IPv4 and IPv6 packets.</li> <li>• <b>qos-group</b>—Matches to a QoS group.</li> <li>• <b>vlan</b>—Matches to a VLAN.</li> </ul>
<b>Step 4</b>	<p><b>policy-map</b> <i>policy-map-name</i></p> <p><b>Example:</b></p> <pre>Device (config) # policy-map flowit Device (config-pmap) #</pre>	<p>Creates a policy map by entering the policy map name, and enters policy-map configuration mode.</p> <p>By default, no policy maps are defined.</p>
<b>Step 5</b>	<p><b>class</b> { <i>class-map-name</i>   <b>class-default</b> }</p> <p><b>Example:</b></p> <pre>Device (config-pmap) # class ipclass1 Device (config-pmap-c) #</pre>	<p>Defines a traffic classification, and enter policy-map class configuration mode.</p> <p>By default, no policy map class-maps are defined.</p> <p>If a traffic class has already been defined by using the <b>class-map</b> global configuration command, specify its name for <i>class-map-name</i> in this command.</p> <p>A <b>class-default</b> traffic class is predefined and can be added to any policy. It is always placed at the end of a policy map. With an implied <b>match any</b> included in the <b>class-default</b> class, all packets that have not already matched the other traffic classes will match <b>class-default</b>.</p>

	Command or Action	Purpose
<b>Step 6</b>	<p><b>set</b> { <b>cos</b>   <b>dscp</b>   <b>ip</b>   <b>precedence</b>   <b>qos-group</b>   <b>wlan user-priority</b> }</p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# <b>set dscp 45</b> Device(config-pmap-c)#</pre>	<p>(Optional) Sets the QoS values. Possible QoS configuration values include:</p> <ul style="list-style-type: none"> <li>• <b>cos</b>—Sets the IEEE 802.1Q/ISL class of service/user priority.</li> <li>• <b>dscp</b>—Sets DSCP in IP(v4) and IPv6 packets.</li> <li>• <b>ip</b>—Sets IP specific values.</li> <li>• <b>precedence</b>—Sets precedence in IP(v4) and IPv6 packet.</li> <li>• <b>qos-group</b>—Sets QoS group.</li> <li>• <b>wlan user-priority</b>—Sets WLAN user priority.</li> </ul> <p>In this example, the <b>set dscp</b> command classifies the IP traffic by setting a new DSCP value in the packet.</p>
<b>Step 7</b>	<p><b>police</b> { <i>target_bit_rate</i>   <b>cir</b>   <b>rate</b> }</p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# <b>police 100000</b> <b>conform-action transmit exceed-action drop</b> Device(config-pmap-c)#</pre>	<p>(Optional) Configures the policer:</p> <ul style="list-style-type: none"> <li>• <i>target_bit_rate</i>—Specifies the bit rate per second, enter a value between 8000 and 10000000000.</li> <li>• <b>cir</b>—Committed Information Rate.</li> <li>• <b>rate</b>—Specifies the police rate, PCR for hierarchical policies, or SCR for single-level ATM 4.0 policer policies.</li> </ul> <p>In this example, the <b>police</b> command adds a policer to the class where any traffic beyond the 100000 set target bit rate is dropped.</p>
<b>Step 8</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# <b>exit</b></pre>	Returns to policy map configuration mode.
<b>Step 9</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-pmap)# <b>exit</b></pre>	Returns to global configuration mode.
<b>Step 10</b>	<p><b>interface</b> <i>interface-id</i></p> <p><b>Example:</b></p>	Specifies the port to attach to the policy map, and enters interface configuration mode.

	Command or Action	Purpose
	Device (config)# <b>interface</b> <b>gigabitethernet 2/0/1</b>	Valid interfaces include physical ports.
<b>Step 11</b>	<b>service-policy input</b> <i>policy-map-name</i> <b>Example:</b> Device (config-if)# <b>service-policy</b> <b>input flowit</b>	Specifies the policy-map name, and applies it to an ingress port. Only one policy map per ingress port is supported.
<b>Step 12</b>	<b>end</b> <b>Example:</b> Device (config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 13</b>	<b>show policy-map</b> [ <i>policy-map-name</i> [ <b>class</b> <i>class-map-name</i> ]] <b>Example:</b> Device# <b>show policy-map</b>	(Optional) Verifies your entries.
<b>Step 14</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy-running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

**What to do next**

If applicable to your QoS configuration, configure classification, policing, and marking of traffic on SVIs by using policy maps.

**Classifying, Policing, and Marking Traffic on SVIs by Using Policy Maps (CLI)****Before you begin**

You should have already decided upon the classification, policing, and marking of your network traffic by using policy maps prior to beginning this procedure.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <b>configure terminal</b>	
<b>Step 2</b>	<b>class-map</b> { <i>class-map name</i>   <b>match-any</b> } <b>Example:</b> Device (config)# <b>class-map class_vlan100</b>	Enters class map configuration mode. <ul style="list-style-type: none"> <li>Creates a class map to be used for matching packets to the class whose name you specify.</li> <li>If you specify <b>match-any</b>, one of the match criteria must be met for traffic entering the traffic class to be classified as part of the traffic class. This is the default.</li> </ul>
<b>Step 3</b>	<b>match vlan</b> <i>vlan number</i> <b>Example:</b> Device (config-cmap)# <b>match vlan 100</b> Device (config-cmap)# <b>exit</b> Device (config)#	Specifies the VLAN to match to the class map.
<b>Step 4</b>	<b>policy-map</b> <i>policy-map-name</i> <b>Example:</b> Device (config)# <b>policy-map policy_vlan100</b> Device (config-pmap)#	Creates a policy map by entering the policy map name, and enters policy-map configuration mode.  By default, no policy maps are defined.
<b>Step 5</b>	<b>description</b> <i>description</i> <b>Example:</b> Device (config-pmap)# <b>description vlan 100</b>	(Optional) Enters a description of the policy map.
<b>Step 6</b>	<b>class</b> { <i>class-map-name</i>   <b>class-default</b> } <b>Example:</b> Device (config-pmap)# <b>class class_vlan100</b> Device (config-pmap-c)#	Defines a traffic classification, and enters the policy-map class configuration mode.  By default, no policy map class-maps are defined.  If a traffic class has already been defined by using the <b>class-map</b> global configuration command, specify its name for <i>class-map-name</i> in this command.  A <b>class-default</b> traffic class is predefined and can be added to any policy. It is always placed at the end of a policy map. With an implied

	Command or Action	Purpose
		<b>match any</b> included in the <b>class-default</b> class, all packets that have not already matched the other traffic classes will match <b>class-default</b> .
<b>Step 7</b>	<p><b>set</b> { <b>cos</b>   <b>dscp</b>   <b>ip</b>   <b>precedence</b>   <b>qos-group</b>   <b>wlan user-priority</b> }</p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# set dscp af23 Device(config-pmap-c)#</pre>	<p>(Optional) Sets the QoS values. Possible QoS configuration values include:</p> <ul style="list-style-type: none"> <li>• <b>cos</b>—Sets the IEEE 802.1Q/ISL class of service/user priority.</li> <li>• <b>dscp</b>—Sets DSCP in IP(v4) and IPv6 packets.</li> <li>• <b>ip</b>—Sets IP specific values.</li> <li>• <b>precedence</b>—Sets precedence in IP(v4) and IPv6 packet.</li> <li>• <b>qos-group</b>—Sets QoS group.</li> <li>• <b>wlan user-priority</b>—Sets WLAN user-priority.</li> </ul> <p>In this example, the <b>set dscp</b> command classifies the IP traffic by matching the packets with a DSCP value of AF23 (010010).</p>
<b>Step 8</b>	<p><b>police</b> { <i>target_bit_rate</i>   <b>cir</b>   <b>rate</b> }</p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# police 200000 conform-action transmit exceed-action drop Device(config-pmap-c)#</pre>	<p>(Optional) Configures the policer:</p> <ul style="list-style-type: none"> <li>• <i>target_bit_rate</i>—Specifies the bit rate per second. Enter a value between 8000 and 10000000000.</li> <li>• <b>cir</b>—Committed Information Rate.</li> <li>• <b>rate</b>—Specifies the police rate, PCR for hierarchical policies, or SCR for single-level ATM 4.0 policer policies.</li> </ul> <p>In this example, the <b>police</b> command adds a policer to the class where any traffic beyond the 200000 set target bit rate is dropped.</p>
<b>Step 9</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# exit</pre>	Returns to policy map configuration mode.
<b>Step 10</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-pmap)# exit</pre>	Returns to global configuration mode.



	Command or Action	Purpose
<b>Step 11</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> <pre>Device(config)# interface gigabitethernet 1/0/3</pre>	Specifies the port to attach to the policy map, and enters interface configuration mode.  Valid interfaces include physical ports.
<b>Step 12</b>	<b>service-policy input</b> <i>policy-map-name</i> <b>Example:</b> <pre>Device(config-if)# service-policy input policy_vlan100</pre>	Specifies the policy-map name, and applies it to an ingress port. Only one policy map per ingress port is supported.
<b>Step 13</b>	<b>end</b> <b>Example:</b> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.
<b>Step 14</b>	<b>show policy-map</b> [ <i>policy-map-name</i> [ <b>class</b> <i>class-map-name</i> ]] <b>Example:</b> <pre>Device# show policy-map</pre>	(Optional) Verifies your entries.
<b>Step 15</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy-running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Policy Map on VLANs](#), on page 1342

[Examples: Policer VLAN Configuration](#), on page 1426

**Configuring Table Maps (CLI)**

Table maps are a form of marking, and also enable the mapping and conversion of one field to another using a table. For example, a table map can be used to map and convert a Layer 2 CoS setting to a precedence value in Layer 3.

**Note**

- A table map can be referenced in multiple policies or multiple times in the same policy.
- A table map configured for a custom output policy under the default class-map, takes affect for all DSCP traffic regardless of which class map the traffic is classified for. The workaround is to remove the table map and configure the **set dscp** command under the default class to change the DSCP marking for classified traffic. If there is any non-queuing action (policer or marking) on a user-defined class, then the packet retains its value or remarks in the user-defined class itself.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<b>table-map name {default {default value   copy   ignore}   exit   map {from from value to to value }   no}</b> <b>Example:</b> <pre>Device(config)# table-map table01 Device(config-tablemap)#</pre>	Creates a table map and enters the table map configuration mode. In table map configuration mode, you can perform the following tasks: <ul style="list-style-type: none"> <li>• <b>default</b>—Configures the table map default value, or sets the default behavior for a value not found in the table map to copy or ignore.</li> <li>• <b>exit</b>—Exits from the table map configuration mode.</li> <li>• <b>map</b>—Maps a <i>from</i> to a <i>to</i> value in the table map.</li> <li>• <b>no</b>—Negates or sets the default values of the command.</li> </ul>
<b>Step 3</b>	<b>map from value to value</b> <b>Example:</b> <pre>Device(config-tablemap)# map from 0 to 2 Device(config-tablemap)# map from 1 to 4 Device(config-tablemap)# map from 24 to 3 Device(config-tablemap)# map from 40 to 6 Device(config-tablemap)# default 0 Device(config-tablemap)#</pre>	In this step, packets with DSCP values 0 are marked to the CoS value 2, DSCP value 1 to the CoS value 4, DSCP value 24 to the CoS value 3, DSCP value 40 to the CoS value 6 and all others to the CoS value 0. <b>Note</b> The mapping from CoS values to DSCP values in this example is configured by using the <b>set</b> policy map class configuration command as described in a later step in this procedure.

	Command or Action	Purpose
<b>Step 4</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-tablemap)# exit Device(config)#</pre>	Returns to global configuration mode.
<b>Step 5</b>	<b>exit</b> <b>Example:</b> <pre>Device(config) exit Device#</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show table-map</b> <b>Example:</b> <pre>Device# show table-map Table Map table01   from 0 to 2   from 1 to 4   from 24 to 3   from 40 to 6   default 0</pre>	Displays the table map configuration.
<b>Step 7</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal Device(config)#</pre>	Enters global configuration mode.
<b>Step 8</b>	<b>policy-map</b> <b>Example:</b> <pre>Device(config)# policy-map table-policy Device(config-pmap)#</pre>	Configures the policy map for the table map.
<b>Step 9</b>	<b>class class-default</b> <b>Example:</b> <pre>Device(config-pmap)# class class-default Device(config-pmap-c)#</pre>	Matches the class to the system default.
<b>Step 10</b>	<b>set cos dscp table <i>table map name</i></b> <b>Example:</b>	If this policy is applied on input port, that port will have trust DSCP enabled on that port and

	Command or Action	Purpose
	<pre>Device (config-pmap-c) # set cos dscp table table01 Device (config-pmap-c) #</pre>	marking will take place depending upon the specified table map.
<b>Step 11</b>	<pre>end  Example:  Device (config-pmap-c) # end Device#</pre>	Returns to privileged EXEC mode.

**What to do next**

Configure any additional policy maps for QoS for your network. After creating your policy maps, attach the traffic policy or polices to an interface using the **service-policy** command.

**Related Topics**

[Table Map Marking](#), on page 1345

[Examples: Table Map Marking Configuration](#), on page 1428

## Configuring Trust

### Configuring Trust Behavior for Wireless Traffic (CLI)

The Cisco IOS XE 3.2 Release supported different trust defaults for wired and wireless ports. The trust default for wired ports was the same as for this software release. For wireless ports, the default system behavior was non-trust, which meant that when the device came up, all markings for the wireless ports were defaulted to zero and no traffic received priority treatment. For compatibility with an existing wired device, all traffic went to the best-effort queue by default. The access point performed priority queuing by default. In the downstream direction, the access point maintained voice, video, best-effort, and background queues for queuing. The access selected the queuing strategy based on the 11e tag information. By default, the access point treated all wireless packets as best effort.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<pre>configure terminal  Example:  Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<pre>qos wireless-default-untrust  Example:  Device (config)# qos wireless-default-untrust</pre>	Configures the behavior of the device to untrust wireless traffic. To configure the device to trust wireless traffic by default, use the <b>no</b> form of the command.

	Command or Action	Purpose
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

**Related Topics**

[Trust Behavior for Wired and Wireless Ports](#), on page 1354

## Configuring QoS Features and Functionality

### Configuring Call Admission Control (CLI)

This task explains how to configure class-based, unconditional packet marking features on your device for Call Admission Control (CAC).

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>class-map class name</b> <b>Example:</b> Device(config)# <b>class-map voice</b> Device(config-cmap)#	Enters policy class map configuration mode. Specifies the name of the class whose policy you want to create or change. Command options for policy class map configuration mode include the following: <ul style="list-style-type: none"> <li>• <i>word</i>—Class map name.</li> <li>• <b>class-default</b>—System default class matching any otherwise unclassified packets.</li> </ul>
<b>Step 3</b>	<b>match dscp dscp value</b> <b>Example:</b> Device(config-cmap)# <b>match dscp 46</b>	(Optional) Matches the DSCP values in IPv4 and IPv6 packets.
<b>Step 4</b>	<b>exit</b> <b>Example:</b> Device(config-cmap)# <b>exit</b> Device(config)#	Returns to global configuration mode.

	Command or Action	Purpose
<b>Step 5</b>	<b>class-map</b> <i>class name</i> <b>Example:</b> <pre>Device(config)# class-map video Device(config-cmap)#</pre>	Enters policy class map configuration mode. Specifies the name of the class whose policy you want to create or change. Command options for policy class map configuration mode include the following: <ul style="list-style-type: none"> <li>• <i>word</i>—Class map name.</li> <li>• <b>class-default</b>—System default class matching any otherwise unclassified packets.</li> </ul>
<b>Step 6</b>	<b>match dscp</b> <i>dscp value</i> <b>Example:</b> <pre>Device(config-cmap)# match dscp 34</pre>	(Optional) Matches the DSCP values in IPv4 and IPv6 packets.
<b>Step 7</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-cmap)# exit Device(config)#</pre>	Returns to global configuration mode.
<b>Step 8</b>	<b>table-map</b> <i>name</i> <b>Example:</b> <pre>Device(config)# table-map dscp2dscp Device(config-tablemap)#</pre>	Creates a table map and enters the table map configuration mode.
<b>Step 9</b>	<b>default copy</b> <b>Example:</b> <pre>Device(config-tablemap)# default copy</pre>	Sets the default behavior for value not found in the table map to copy. <p><b>Note</b> This is the default option. You can also do a mapping of values for DSCP to DSCP.</p>
<b>Step 10</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-tablemap)# exit Device(config)#</pre>	Returns to global configuration mode.
<b>Step 11</b>	<b>table-map</b> <i>name</i> <b>Example:</b> <pre>Device(config)# table-map dscp2up</pre>	Creates a new table map and enters the table map configuration mode.

	Command or Action	Purpose
	Device (config-tablemap) #	
<b>Step 12</b>	<b>default copy</b> <b>Example:</b> Device (config-tablemap) # <b>default copy</b>	Sets the default behavior for value not found in the table map to copy.  <b>Note</b> This is the default option. You can also do a mapping of values for DSCP to UP.
<b>Step 13</b>	<b>exit</b> <b>Example:</b> Device (config-tablemap) # <b>exit</b> Device (config) #	Returns to global configuration mode.
<b>Step 14</b>	<b>policy-map <i>policy name</i></b> <b>Example:</b> Device (config) # <b>policy-map</b> <b>ssid_child_cac</b> Device (config-pmap) #	Enters policy map configuration mode.  Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.
<b>Step 15</b>	<b>class <i>class-map-name</i></b> <b>Example:</b> Device (config-pmap) # <b>class voice</b>	Defines an interface-level traffic classification, and enters policy-map configuration mode.
<b>Step 16</b>	<b>priority level <i>level_value</i></b> <b>Example:</b> Device (config-pmap-c) # <b>priority level</b> <b>1</b>	The <b>priority</b> command assigns a strict scheduling priority for the class.  <b>Note</b> Priority level 1 is more important than priority level 2. Priority level 1 reserves bandwidth that is processed first for QoS, so its latency is very low. Both priority level 1 and 2 reserve bandwidth.
<b>Step 17</b>	<b>police [<i>target_bit_rate</i>   <b>cir</b>   <b>rate</b> ]</b> <b>Example:</b> Device (config-pmap-c) # <b>police cir 10m</b>	(Optional) Configures the policer: <ul style="list-style-type: none"> <li>• <b><i>target_bit_rate</i></b>—Specifies the bit rate per second. Enter a value between 8000 and 10000000000.</li> <li>• <b>cir</b>—Committed Information Rate.</li> <li>• <b>rate</b>—Specifies the police rate, PCR for hierarchical policies, or SCR for single-level ATM 4.0 policer policies.</li> </ul>

	Command or Action	Purpose
<b>Step 18</b>	<b>admit cac wmm-tspec</b> <b>Example:</b> <pre>Device(config-pmap-c) # admit cac wmm-tspec Device(config-pmap-cac-wmm) #</pre>	Configures call admission control for the policy map. <b>Note</b> This command only configures CAC for wireless QoS.
<b>Step 19</b>	<b>rate value</b> <b>Example:</b> <pre>Device(config-pmap-admit-cac-wmm) # rate 5000</pre>	Configures the target bit rate (Kilo Bits per second). Enter a value from 8 to 10000000.
<b>Step 20</b>	<b>wlan-up value</b> <b>Example:</b> <pre>Device(config-pmap-admit-cac-wmm) # wlan-up 6 7</pre>	Configures the WLAN UP value. Enter a value from 0 to 7.
<b>Step 21</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-pmap-admit-cac-wmm) # exit Device(config-pmap-c) #</pre>	Returns to policy map class configuration mode.
<b>Step 22</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-pmap-c) # exit Device(config-pmap) #</pre>	Returns to policy map configuration mode.
<b>Step 23</b>	<b>class class name</b> <b>Example:</b> <pre>Device(config-pmap) # class video Device(config-pmap-c) #</pre>	Enters policy class map configuration mode. Specifies the name of the class whose policy you want to create or change. Command options for policy class map configuration mode include the following: <ul style="list-style-type: none"> <li>• <i>word</i>—Class map name.</li> <li>• <b>class-default</b>—System default class matching any otherwise unclassified packets.</li> </ul>
<b>Step 24</b>	<b>priority level level_value</b> <b>Example:</b>	The <b>priority</b> command assigns a strict scheduling priority for the class.



	Command or Action	Purpose
	Device (config-pmap-c) # <b>priority level 2</b>	<b>Note</b> Priority level 1 is more important than priority level 2. Priority level 1 reserves bandwidth that is processed first for QoS, so its latency is very low. Both priority level 1 and 2 reserve bandwidth.
<b>Step 25</b>	<b>police</b> [ <i>target_bit_rate</i>   <b>cir</b>   <b>rate</b> ] <b>Example:</b> Device (config-pmap-c) # <b>police cir 20m</b>	(Optional) Configures the policer: <ul style="list-style-type: none"> <li>• <i>target_bit_rate</i>—Specifies the bit rate per second. Enter a value between 8000 and 10000000000.</li> <li>• <b>cir</b>—Committed Information Rate.</li> <li>• <b>rate</b>—Specifies the police rate, PCR for hierarchical policies, or SCR for single-level ATM 4.0 policer policies.</li> </ul>
<b>Step 26</b>	<b>admit cac wmm-tspec</b> <b>Example:</b> Device (config-pmap-c) # <b>admit cac wmm-tspec</b> Device (config-pmap-admit-cac-wmm) #	Configures call admission control for the policy map. <b>Note</b> This command only configures CAC for wireless QoS.
<b>Step 27</b>	<b>rate value</b> <b>Example:</b> Device (config-pmap-admit-cac-wmm) # <b>rate 5000</b>	Configures the target bit rate (Kilo Bits per second). Enter a value from 8 to 10000000.
<b>Step 28</b>	<b>wlan-up value</b> <b>Example:</b> Device (config-pmap-admit-cac-wmm) # <b>wlan-up 4 5</b>	Configures the WLAN UP value. Enter a value from 0 to 7.
<b>Step 29</b>	<b>exit</b> <b>Example:</b> Device (config-pmap-cac-wmm) # <b>exit</b> Device (config-pmap) #	Returns to policy map configuration mode.
<b>Step 30</b>	<b>exit</b> <b>Example:</b>	Returns to global configuration mode.

	Command or Action	Purpose
	Device (config-pmap) # <b>exit</b> Device (config) #	
<b>Step 31</b>	<b>policy-map</b> <i>policy name</i>  <b>Example:</b>  Device (config) # <b>policy-map ssid_cac</b> Device (config-pmap) #	Enters policy map configuration mode.  Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.
<b>Step 32</b>	<b>class</b> <i>class-map-name</i>  <b>Example:</b>  Device (config-pmap) # <b>class default</b>	Defines an interface-level traffic classification, and enters policy-map configuration mode.  In this example, the class map is set to default.
<b>Step 33</b>	<b>set dscp dscp table</b> <i>table_map_name</i>  <b>Example:</b>  Device (config-pmap-c) # <b>set dscp dscp table dscp2dscp</b>	(Optional) Sets the QoS values. In this example, the <b>set dscp dscp table</b> command creates a table map and sets its values.
<b>Step 34</b>	<b>set wlan user-priority dscp table</b> <i>table_map_name</i>  <b>Example:</b>  Device (config-pmap-c) # <b>set wlan user-priority dscp table dscp2up</b>	(Optional) Sets the QoS values. In this example, the <b>set wlan user-priority dscp table</b> command sets the WLAN user priority.
<b>Step 35</b>	<b>shape average</b> { <i>target bit rate</i>   <b>percent percentage</b> }  <b>Example:</b>  Device (config-pmap-c) # <b>shape average 100000000</b>	Configures the average shape rate. You can configure the average shape rate by target bit rates (bits per second) or by percentage of interface bandwidth for the Committed Information Rate (CIR).
<b>Step 36</b>	<b>queue-buffers</b> { <i>ratio ratio value</i> }  <b>Example:</b>  Device (config-pmap-c) # <b>queue-buffers ratio 0</b>	Configures the relative buffer size for the queue.  <b>Note</b> The sum of all configured buffers in a policy must be less than or equal to 100 percent. Unallocated buffers are evenly distributed to all the remaining queues. Ensure sufficient buffers are allocated to all queues including the priority queues.

	Command or Action	Purpose
		<b>Note</b> Protocol Data Units (PDUs) for network control protocols such as spanning-tree and LACP utilize the priority queue or queue 0 (when a priority queue is not configured). Ensure sufficient buffers are allocated to these queues for the protocols to function.
<b>Step 37</b>	<b>service-policy</b> <i>policy_map_name</i> <b>Example:</b> <pre>Device(config-pmap-c) # <b>service-policy</b>   ssid_child_cac</pre>	Specifies the policy map for the service policy.
<b>Step 38</b>	<b>end</b> <b>Example:</b> <pre>Device(config-pmap) # <b>end</b> Device#</pre>	Saves configuration changes.
<b>Step 39</b>	<b>show policy-map</b> <b>Example:</b> <pre>Device# <b>show policy-map</b></pre>	(Optional) Displays policy configuration information for all classes configured for all service policies.

**What to do next**

Configure any additional policy maps for QoS for your network. After creating your policy maps, attach the traffic policy or policies to an interface using the **service-policy** command.

For additional information about CAC, refer to the *System Management Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)*.

**Configuring Bandwidth (CLI)**

This procedure explains how to configure bandwidth on your .

**Before you begin**

You should have created a class map for bandwidth before beginning this procedure.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>policy-map <i>policy name</i></b> <b>Example:</b> Device(config)# <b>policy-map</b> <b>policy_bandwidth01</b> Device(config-pmap)#	Enters policy map configuration mode.  Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.
<b>Step 3</b>	<b>class <i>class name</i></b> <b>Example:</b> Device(config-pmap)# <b>class</b> <b>class_bandwidth01</b> Device(config-pmap-c)#	Enters policy class map configuration mode. Specifies the name of the class whose policy you want to create or change. Command options for policy class map configuration mode include the following: <ul style="list-style-type: none"> <li>• <i>word</i>—Class map name.</li> <li>• <b>class-default</b>—System default class matching any otherwise unclassified packets.</li> </ul>
<b>Step 4</b>	<b>bandwidth {<i>Kb/s</i>   <b>percent</b> <i>percentage</i>   <b>remaining</b> { <i>ratio</i> <i>ratio</i> }}</b> <b>Example:</b> Device(config-pmap-c)# <b>bandwidth 200000</b> Device(config-pmap-c)#	Configures the bandwidth for the policy map. The parameters include: <ul style="list-style-type: none"> <li>• <i>Kb/s</i>—Configures a specific value in kilobits per second (from 20000 to 10000000).</li> <li>• <b>percent</b>—Allocates minimum bandwidth to a particular class based on a percentage. The queue can oversubscribe bandwidth in case other queues do not utilize the entire port bandwidth. The total sum cannot exceed 100 percent, and in case it is less than 100 percent, the rest of the bandwidth is equally divided along all bandwidth queues.</li> <li>• <b>remaining</b>— Allocates minimum bandwidth to a particular class. The queue can oversubscribe bandwidth in case other queues do not utilize entire port bandwidth. The total sum cannot exceed 100 percent. It is preferred to use this command when the <b>priority</b> command is used for certain</li> </ul>

	Command or Action	Purpose
		<p>queues in the policy. You can also assign ratios rather than percentages to each queue; the queues will be assigned certain weights which are inline with these ratios. Ratios can range from 0 to 100. Total bandwidth ratio allocation for the policy in this case can exceed 100.</p> <p><b>Note</b> You cannot mix bandwidth types on a policy map. For example, you cannot configure bandwidth in a single policy map using both a bandwidth percent and in kilobits per second.</p>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-pmap-c) # end Device#</pre>	Saves configuration changes.
<b>Step 6</b>	<p><b>show policy-map</b></p> <p><b>Example:</b></p> <pre>Device# show policy-map</pre>	(Optional) Displays policy configuration information for all classes configured for all service policies.

**What to do next**

Configure any additional policy maps for QoS for your network. After creating the policy maps, attach the traffic policy or policies to an interface using the **service-policy** command.

**Related Topics**

[Bandwidth](#), on page 1350

**Configuring Police (CLI)**

This procedure explains how to configure policing on your .

**Before you begin**

You should have created a class map for policing before beginning this procedure.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 2</b>	<p><code>policy-map <i>policy name</i></code></p> <p><b>Example:</b></p> <pre>Device(config)# policy-map policy_police01 Device(config-pmap)#</pre>	<p>Enters policy map configuration mode.</p> <p>Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.</p>
<b>Step 3</b>	<p><code>class <i>class name</i></code></p> <p><b>Example:</b></p> <pre>Device(config-pmap)# class class_police01 Device(config-pmap-c)#</pre>	<p>Enters policy class map configuration mode. Specifies the name of the class whose policy you want to create or change. Command options for policy class map configuration mode include the following:</p> <ul style="list-style-type: none"> <li>• <i>word</i>—Class map name.</li> <li>• <b>class-default</b>—System default class matching any otherwise unclassified packets.</li> </ul>
<b>Step 4</b>	<p><code>police {<i>target_bit_rate</i> [<i>burst bytes</i>   <b>bc</b>   <b>conform-action</b>   <b>pir</b> ]   <b>cir</b> {<i>target_bit_rate</i>   <b>percent</b> <i>percentage</i>}   <b>rate</b> {<i>target_bit_rate</i>   <b>percent</b> <i>percentage</i>} <b>conform-action</b> <b>transmit</b> <b>exceed-action</b> {<b>drop</b> [<i>violate action</i>]   <b>set-cos-transmit</b>   <b>set-dscp-transmit</b>   <b>set-prec-transmit</b>   <b>transmit</b> [<i>violate action</i>]} }</code></p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# police 8000 conform-action transmit exceed-action drop Device(config-pmap-c)#</pre>	<p>The following <b>police</b> subcommand options are available:</p> <ul style="list-style-type: none"> <li>• <i>target_bit_rate</i>—Bits per second (from 8000 to 10000000000).</li> <li>• <i>burst bytes</i>—Enter a value from 1000 to 512000000.</li> <li>• <b>bc</b>—Conform burst.</li> <li>• <b>conform-action</b>—Action taken when rate is less than conform burst.</li> <li>• <b>pir</b>—Peak Information Rate.</li> <li>• <b>cir</b>—Committed Information Rate. <ul style="list-style-type: none"> <li>• <i>target_bit_rate</i>—Target bit rate (8000 to 100000000000).</li> <li>• <b>percent</b>—Percentage of interface bandwidth for CIR.</li> </ul> </li> <li>• <b>rate</b>—Specifies the police rate, PCR for hierarchical policies, or SCR for single-level ATM 4.0 policer policies. <ul style="list-style-type: none"> <li>• <i>target_bit_rate</i>—Target Bit Rate (8000 to 10000000000).</li> </ul> </li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>percent</b>—Percentage of interface bandwidth for rate.</li> </ul> <p>The following <b>police conform-action transmit exceed-action</b> subcommand options are available:</p> <ul style="list-style-type: none"> <li>• <b>drop</b>—Drops the packet.</li> <li>• <b>set-cos-transmit</b>—Sets the CoS value and sends it.</li> <li>• <b>set-dscp-transmit</b>—Sets the DSCP value and sends it.</li> <li>• <b>set-prec-transmit</b>—Rewrites the packet precedence and sends it.</li> <li>• <b>transmit</b>—Transmits the packet.</li> </ul> <p><b>Note</b> Policer-based markdown actions are only supported using table maps. Only one markdown table map is allowed for each marking field in the .</p>
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config-pmap-c)# end Device#</pre>	Saves configuration changes.
<b>Step 6</b>	<b>show policy-map</b> <b>Example:</b> <pre>Device# show policy-map</pre>	(Optional) Displays policy configuration information for all classes configured for all service policies. <p><b>Note</b> The <b>show policy-map</b> command output does not display counters for conformed bytes and exceeded bytes</p>

### What to do next

Configure any additional policy maps for QoS for your network. After creating your policy maps, attach the traffic policy or polices to an interface using the **service-policy** command.

### Related Topics

[Single-Rate Two-Color Policing](#), on page 1347

[Examples: Single-Rate Two-Color Policing Configuration](#), on page 1427

[Dual-Rate Three-Color Policing](#), on page 1347

[Examples: Dual-Rate Three-Color Policing Configuration](#), on page 1427

[Policing](#), on page 1343

[Examples: Policing Action Configuration](#), on page 1425

[Token-Bucket Algorithm](#), on page 1343

[Examples: Policing Units](#)

## Configuring Priority (CLI)

This procedure explains how to configure priority on your .

The supports giving priority to specified queues. There are two priority levels available (1 and 2).



**Note** Queues supporting voice and video should be assigned a priority level of 1.

### Before you begin

You should have created a class map for priority before beginning this procedure.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>policy-map <i>policy name</i></b> <b>Example:</b> Device (config)# <b>policy-map</b> <b>policy_priority01</b> Device (config-pmap)#	Enters policy map configuration mode.  Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.
<b>Step 3</b>	<b>class <i>class name</i></b> <b>Example:</b> Device (config-pmap)# <b>class</b> <b>class_priority01</b> Device (config-pmap-c)#	Enters policy class map configuration mode. Specifies the name of the class whose policy you want to create or change. Command options for policy class map configuration mode include the following: <ul style="list-style-type: none"> <li>• <b>word</b>—Class map name.</li> <li>• <b>class-default</b>—System default class matching any otherwise unclassified packets.</li> </ul>
<b>Step 4</b>	<b>priority [Kb/s [<i>burst_in_bytes</i>]   level <i>level_value</i> [Kb/s [<i>burst_in_bytes</i>]   percent <i>percentage</i> [<i>burst_in_bytes</i>] ]   percent <i>percentage</i> [<i>burst_in_bytes</i>] ]</b>	(Optional) The <b>priority</b> command assigns a strict scheduling priority for the class.  The command options include:



	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config-pmap-c)# <b>priority level 1</b> Device(config-pmap-c)#</pre>	<ul style="list-style-type: none"> <li>• <i>Kb/s</i>—Specifies the kilobits per second (from 1 to 2000000).</li> <li>• <i>burst_in_bytes</i>—Specifies the burst in bytes (from 32 to 2000000).</li> <li>• <b>level</b> <i>level_value</i>—Specifies the multilevel (1-2) priority queue. <ul style="list-style-type: none"> <li>• <i>Kb/s</i>—Specifies the kilobits per second (from 1 to 2000000).</li> <li>• <i>burst_in_bytes</i>—Specifies the burst in bytes (from 32 to 2000000).</li> </ul> </li> <li>• <b>percent</b>—Percentage of the total bandwidth. <ul style="list-style-type: none"> <li>• <i>burst_in_bytes</i>—Specifies the burst in bytes (from 32 to 2000000).</li> </ul> </li> <li>• <b>percent</b>—Percentage of the total bandwidth. <ul style="list-style-type: none"> <li>• <i>burst_in_bytes</i>—Specifies the burst in bytes (32 to 2000000).</li> </ul> </li> </ul> <p><b>Note</b> Priority level 1 is more important than priority level 2. Priority level 1 reserves bandwidth that is processed first for QoS, so its latency is very low. Both priority level 1 and 2 reserve bandwidth.</p>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# <b>end</b> Device#</pre>	Saves configuration changes.
<b>Step 6</b>	<p><b>show policy-map</b></p> <p><b>Example:</b></p> <pre>Device# <b>show policy-map</b></pre>	(Optional) Displays policy configuration information for all classes configured for all service policies.

**What to do next**

Configure any additional policy maps for QoS for your network. After creating your policy maps, attach the traffic policy or polices to an interface using the **service-policy** command.

**Related Topics**

[Priority Queues](#), on page 1352

## Configuring Queues and Shaping

### Configuring Egress Queue Characteristics

Depending on the complexity of your network and your QoS solution, you may need to perform all of the procedures in this section. You need to make decisions about these characteristics:

- Which packets are mapped by DSCP, CoS, or QoS group value to each queue and threshold ID?
- What drop percentage thresholds apply to the queues, and how much reserved and maximum memory is needed for the traffic type?
- How much of the fixed buffer space is allocated to the queues?
- Does the bandwidth of the port need to be rate limited?
- How often should the egress queues be serviced and which technique (shaped, shared, or both) should be used?




---

**Note** You can only configure the egress queues on the device.

---

### Configuring Queue Buffers (CLI)

The `queue` command allows you to allocate buffers to queues. If there is no allocation made to buffers, then they are divided equally for all queues. You can use the `queue-buffer` ratio to divide it in a particular ratio. Since by default DTS (Dynamic Threshold and Scaling) is active on all queues, these are soft buffers.

**Before you begin**

The following are prerequisites for this procedure:

- You should have created a class map for the queue buffer before beginning this procedure.
- You must have configured either bandwidth, shape, or priority on the policy map prior to configuring the queue buffers.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 2</b>	<p><code>policy-map <i>policy name</i></code></p> <p><b>Example:</b></p> <pre>Device(config)# <b>policy-map</b> <b>policy_queuebuffer01</b> Device(config-pmap)#</pre>	<p>Enters policy map configuration mode.</p> <p>Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.</p>
<b>Step 3</b>	<p><code>class <i>class name</i></code></p> <p><b>Example:</b></p> <pre>Device(config-pmap)# <b>class</b> <b>class_queuebuffer01</b> Device(config-pmap-c)#</pre>	<p>Enters policy class map configuration mode. Specifies the name of the class whose policy you want to create or change. Command options for policy class map configuration mode include the following:</p> <ul style="list-style-type: none"> <li>• <b>word</b>—Class map name.</li> <li>• <b>class-default</b>—System default class matching any otherwise unclassified packets.</li> </ul>
<b>Step 4</b>	<p><code>bandwidth {<i>Kb/s</i>   <b>percent</b> <i>percentage</i>   <b>remaining</b> { <i>ratio</i> <i>ratio value</i> }}</code></p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# <b>bandwidth percent</b> <b>80</b> Device(config-pmap-c)#</pre>	<p>Configures the bandwidth for the policy map. The command parameters include:</p> <ul style="list-style-type: none"> <li>• <b>Kb/s</b>—Use this command to configure a specific value. The range is 20000 to 10000000.</li> <li>• <b>percent</b>—Allocates a minimum bandwidth to a particular class using a percentage. The queue can oversubscribe bandwidth in case other queues do not utilize the entire port bandwidth. The total sum cannot exceed 100 percent, and in case it is less than 100 percent, the rest of the bandwidth is equally divided along all bandwidth queues.</li> <li>• <b>remaining</b>—Allocates a minimum bandwidth to a particular class. The queue can oversubscribe bandwidth in case other queues do not utilize entire port bandwidth. The total sum cannot exceed 100 percent. It is preferred to use this command when the <b>priority</b> command is used for certain queues in the policy. You can also assign ratios rather than a percentage to each queue; the queues will be assigned certain weights that are inline with these ratios. Ratios can range from 0 to 100. Total</li> </ul>

	Command or Action	Purpose
		bandwidth ratio allocation for the policy in this case can exceed 100. <b>Note</b> You cannot mix bandwidth types on a policy map.
<b>Step 5</b>	<b>queue-buffers</b> {ratio ratio value}  <b>Example:</b>  Device(config-pmap-c)# <b>queue-buffers ratio 10</b> Device(config-pmap-c)#	Configures the relative buffer size for the queue.  <b>Note</b> The sum of all configured buffers in a policy must be less than or equal to 100 percent. Unallocated buffers are evenly distributed to all the remaining queues. Ensure sufficient buffers are allocated to all queues including the priority queues.  <b>Note</b> Protocol Data Units(PDUs) for network control protocols such as spanning-tree and LACP utilize the priority queue or queue 0 (when a priority queue is not configured). Ensure sufficient buffers are allocated to these queues for the protocols to function.
<b>Step 6</b>	<b>end</b>  <b>Example:</b>  Device(config-pmap-c)# <b>end</b> Device#	Saves configuration changes.
<b>Step 7</b>	<b>show policy-map</b>  <b>Example:</b>  Device# <b>show policy-map</b>	(Optional) Displays policy configuration information for all classes configured for all service policies.

**What to do next**

Configure any additional policy maps for QoS for your network. After creating your policy maps, attach the traffic policy or policies to an interface using the **service-policy** command.

**Related Topics**

[Queue Buffer Allocation](#), on page 1353

[Examples: Queue Buffers Configuration](#), on page 1425

**Configuring Queue Limits (CLI)**

You use queue limits to configure Weighted Tail Drop (WTD). WTD ensures the configuration of more than one threshold per queue. Each class of service is dropped at a different threshold value to provide for QoS

differentiation. With the , each queue has 3 explicit programmable threshold classes—0, 1, 2. Therefore, the enqueue/drop decision of each packet per queue is determined by the packet's threshold class assignment, which is determined by the DSCP, CoS, or QoS group field of the frame header.

WTD also uses a soft limit, and therefore you are allowed to configure the queue limit to up to 400 percent (maximum four times the reserved buffer from common pool). This soft limit prevents overrunning the common pool without impacting other features.



**Note** You can only configure queue limits on the egress queues on wired ports.

### Before you begin

The following are prerequisites for this procedure:

- You should have created a class map for the queue limits before beginning this procedure.
- You must have configured either bandwidth, shape, or priority on the policy map prior to configuring the queue limits.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>policy-map <i>policy name</i></b> <b>Example:</b> Device(config)# <b>policy-map</b> <b>policy_queue_limit01</b> Device(config-pmap)#	Enters policy map configuration mode. Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.
<b>Step 3</b>	<b>class <i>class name</i></b> <b>Example:</b> Device(config-pmap)# <b>class</b> <b>class_queue_limit01</b> Device(config-pmap-c)#	Enters policy class map configuration mode. Specifies the name of the class whose policy you want to create or change. Command options for policy class map configuration mode include the following: <ul style="list-style-type: none"> <li>• <b>word</b>—Class map name.</li> <li>• <b>class-default</b>—System default class matching any otherwise unclassified packets.</li> </ul>
<b>Step 4</b>	<b>bandwidth {<i>Kb/s</i>   <b>percent</b> <i>percentage</i>   <b>remaining</b> { <i>ratio</i> <i>ratio value</i> } }</b>	Configures the bandwidth for the policy map. The parameters include:

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config-pmap-c)# bandwidth 500000 Device(config-pmap-c)#</pre>	<ul style="list-style-type: none"> <li>• <b>Kb/s</b>—Use this command to configure a specific value. The range is 20000 to 10000000.</li> <li>• <b>percent</b>—Allocates a minimum bandwidth to a particular class. The queue can oversubscribe bandwidth in case other queues do not utilize the entire port bandwidth. The total sum cannot exceed 100 percent, and in case it is less than 100 percent, the rest of the bandwidth is equally divided along all bandwidth queues.</li> <li>• <b>remaining</b>—Allocates a minimum bandwidth to a particular class. The queue can oversubscribe bandwidth in case other queues do not utilize entire port bandwidth. The total sum cannot exceed 100 percent. It is preferred to use this command when the <b>priority</b> command is used for certain queues in the policy. You can also assign ratios rather than a percentage to each queue; the queues will be assigned certain weights that are inline with these ratios. Ratios can range from 0 to 100. Total bandwidth ratio allocation for the policy in this case can exceed 100.</li> </ul> <p><b>Note</b> You cannot mix bandwidth types on a policy map.</p>
<b>Step 5</b>	<p><b>queue-limit</b> {<i>packets</i> <b>packets</b>   <b>cos</b> {<i>cos value</i>   <b>maximum threshold value</b>   <b>percent percentage</b> }   <b>values</b> {<i>cos value</i>   <b>percent percentage</b> } }   <b>dscp</b> {<i>dscp value</i>   <b>maximum threshold value</b>   <b>percent percentage</b> }   <b>match packet</b> {<i>maximum threshold value</i>   <b>percent percentage</b> }   <b>default</b> {<i>maximum threshold value</i>   <b>percent percentage</b> }   <b>ef</b> {<i>maximum threshold value</i>   <b>percent percentage</b> }   <b>dscp values</b> <i>dscp value</i> }   <b>percent percentage</b> } }</p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# queue-limit dscp 3 percent 20 Device(config-pmap-c)# queue-limit dscp 4 percent 30 Device(config-pmap-c)# queue-limit dscp 5 percent 40</pre>	<p>Sets the queue limit threshold percentage values.</p> <p>With every queue, there are three thresholds (0,1,2), and there are default values for each of these thresholds. Use this command to change the default or any other queue limit threshold setting. For example, if DSCP 3, 4, and 5 packets are being sent into a specific queue in a configuration, then you can use this command to set the threshold percentages for these three DSCP values. For additional information about queue limit threshold values, see <a href="#">Weighted Tail Drop, on page 1351</a>.</p> <p><b>Note</b> The does not support absolute queue-limit percentages. The only supports DSCP or CoS queue-limit percentages.</p>

	Command or Action	Purpose
<b>Step 6</b>	<b>end</b> <b>Example:</b> <pre>Device(config-pmap-c) # end Device#</pre>	Saves configuration changes.
<b>Step 7</b>	<b>show policy-map</b> <b>Example:</b> <pre>Device# show policy-map</pre>	(Optional) Displays policy configuration information for all classes configured for all service policies.

### What to do next

Proceed to configure any additional policy maps for QoS for your network. After creating your policy maps, proceed to attach the traffic policy or policies to an interface using the **service-policy** command.

### Related Topics

[Weighted Tail Drop](#), on page 1351

[Examples: Queue-limit Configuration](#), on page 1424

## Configuring Shaping (CLI)

You use the **shape** command to configure shaping (maximum bandwidth) for a particular class. The queue's bandwidth is restricted to this value even though the port has additional bandwidth left. You can configure shaping as an average percent, as well as a shape average value in bits per second.

### Before you begin

You should have created a class map for shaping before beginning this procedure.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<b>policy-map <i>policy name</i></b> <b>Example:</b> <pre>Device(config) # policy-map policy_shaping01 Device(config-pmap) #</pre>	Enters policy map configuration mode.  Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.

	Command or Action	Purpose
<b>Step 3</b>	<p><b>class</b> <i>class name</i></p> <p><b>Example:</b></p> <pre>Device(config-pmap)# class class_shaping01 Device(config-pmap-c)#</pre>	<p>Enters policy class map configuration mode. Specifies the name of the class whose policy you want to create or change. Command options for policy class map configuration mode include the following:</p> <ul style="list-style-type: none"> <li>• <i>word</i>—Class map name.</li> <li>• <b>class-default</b>—System default class matching any otherwise unclassified packets.</li> </ul>
<b>Step 4</b>	<p><b>shape average</b> {<i>target bit rate</i>   <b>percent</b> <i>percentage</i>}</p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# shape average percent 50 Device(config-pmap-c)#</pre>	<p>Configures the average shape rate. You can configure the average shape rate by target bit rates (bits per second) or by percentage of interface bandwidth for the Committed Information Rate (CIR).</p> <p><b>Note</b> For the egress class-default SSID policy, you must configure the queue buffer ratio as 0 after you configure the average shape rate.</p>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# end Device#</pre>	<p>Saves configuration changes.</p>
<b>Step 6</b>	<p><b>show policy-map</b></p> <p><b>Example:</b></p> <pre>Device# show policy-map</pre>	<p>(Optional) Displays policy configuration information for all classes configured for all service policies.</p>

### What to do next

Configure any additional policy maps for QoS for your network. After creating your policy maps, attach the traffic policy or policies to an interface using the **service-policy** command.

### Related Topics

[Average Rate Shaping](#), on page 1348

[Examples: Average Rate Shaping Configuration](#), on page 1423

[Hierarchical Shaping](#), on page 1349

## Configuring Precious Metal Policies (CLI)

You can configure precious metal QoS policies on a per-WLAN basis.



## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan wlan-name</b> <b>Example:</b> Device# <code>wlan test4</code>	Enters the WLAN configuration submenu.
<b>Step 3</b>	<b>service-policy {input   output}</b> <i>policy-name</i> <b>Example:</b> Device(config-wlan)# <code>service-policy output platinum</code> <b>Example:</b> Device(config-wlan)# <code>service-policy input platinum-up</code>	Configures the WLAN with the QoS policy. To configure the WLAN with precious metal policies, you must enter one of the following keywords: <b>platinum</b> , <b>gold</b> , <b>silver</b> , or <b>bronze</b> . The upstream policy is specified with the keyword <b>platinum-up</b> as shown in the example. <b>Note</b> Upstream policies differ from downstream policies. The upstream policies have a suffix of -up.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit the global configuration mode.
<b>Step 5</b>	<b>show wlan {wlan-id   wlan-name}</b> <b>Example:</b> Device# <code>show wlan name qos-wlan</code>	Verifies the configured QoS policy on the WLAN.  Device# <code>show wlan name qos-wlan</code> . . .  QoS Service Policy - Input Policy Name : platinum-up Policy State : Validated QoS Service Policy - Output Policy Name : platinum Policy State : Validated . . .

## Related Topics

[Precious Metal Policies for Wireless QoS](#), on page 1357

# Monitoring QoS

The following commands can be used to monitor QoS on the .

**Table 101: Monitoring QoS**

Command	Description
<b>show class-map</b> [ <i>class_map_name</i> ]	Displays a list of all class maps configured.
<b>show class-map type control subscriber</b> { <b>all</b>   <i>name</i> } <b>show class-map type control subscriber detail</b>	Displays control class map and statistics. <ul style="list-style-type: none"> <li>• <b>all</b>—Displays information for all class maps.</li> <li>• <b>name</b>—Displays configured class maps.</li> </ul>
<b>show policy-map</b> [ <i>policy_map_name</i> ]	Displays a list of all policy maps configured. Command parameters include: <ul style="list-style-type: none"> <li>• <b>policy map name</b></li> <li>• <b>interface</b></li> <li>• <b>session</b></li> </ul>

Command	Description
<b>show policy-map interface</b> { <b>Auto-template</b>   <b>Capwap</b>   <b>GigabitEthernet</b>   <b>GroupVI</b>   <b>InternalInterface</b>   <b>Lspvif</b>   <b>Loopback</b>   <b>Null</b>   <b>Port-channel</b>   <b>TenGigabitEthernet</b>   <b>Tunnel</b>   <b>Vlan</b>   <b>brief</b>   <b>class</b>   <b>input</b>   <b>output</b>   <b>wireless</b> }	Displays the runtime representation and statistics of all the policies configured on the . Command parameters include: <ul style="list-style-type: none"> <li>• <b>Auto-template</b>—Auto-Template interface</li> <li>• <b>Capwap</b>—CAPWAP tunnel interface</li> <li>• <b>GigabitEthernet</b>—Gigabit Ethernet IEEE.802.3z</li> <li>• <b>GroupVI</b>—Group virtual interface</li> <li>• <b>InternalInterface</b>—Internal interface</li> <li>• <b>Loopback</b>—Loopback interface</li> <li>• <b>Null</b>—Null interface</li> <li>• <b>Lspvif</b>—LSP virtual interface</li> <li>• <b>Port-channel</b>—Ethernet channel of interfaces</li> <li>• <b>TenGigabitEthernet</b>—10-Gigabit Ethernet</li> <li>• <b>Tunnel</b>—Tunnel interface</li> <li>• <b>Vlan</b>—Catalyst VLANs</li> <li>• <b>brief</b>—Brief description of policy maps</li> <li>• <b>class</b>—Statistics for individual class</li> <li>• <b>input</b>—Input policy</li> <li>• <b>output</b>—Output policy</li> <li>• <b>wireless</b>—wireless</li> </ul>
<b>show policy-map interface wireless ap</b> [ <i>access point</i> ]	Displays the runtime representation and statistics for all the wireless APs on the .
<b>show policy-map interface wireless ssid</b> [ <i>ssid</i> ]	Displays the runtime representation and statistics for all the SSID targets on the .

Command	Description
<b>show policy-map interface wireless client mac</b> [ <i>mac_address</i> ]	Displays the runtime representation and statistics for all the client targets on the .
<b>show policy-map session</b> [ <b>input</b>   <b>output</b>   <b>uid</b> <i>UUID</i> ]	Displays the session QoS policy. Command parameters include: <ul style="list-style-type: none"> <li>• <b>input</b>—Input policy</li> <li>• <b>output</b>—Output policy</li> <li>• <b>uid</b>—Policy based on SSS unique identification.</li> </ul>
<b>show policy-map type control subscriber</b> { <b>all</b>   <b>name</b> }	Displays the type QoS policy-map.
<b>show table-map</b>	Displays all the table maps and their configurations.
<b>show platform qos wireless</b> { <b>afd</b> { <b>client</b>   <b>ssid</b> }   <b>stats</b> { <b>bssid</b> <i>bssid-value</i>   <b>client</b> <i>client name</i>   <b>ssid</b> { <i>ssid-value</i>   <b>all</b> } <b>client</b> <b>all</b> }}	Displays wireless targets. The following command parameters are supported: <ul style="list-style-type: none"> <li>• <b>afd</b>—AFD information</li> <li>• <b>stats</b>—Statistics information</li> </ul>
<b>show policy-map interface wireless ssid name</b> <i>ssid-name</i> [ <b>radio type</b> { <b>24ghz</b>   <b>5ghz</b> } <b>ap name</b> <i>ap-name</i>   <b>ap name</b> <i>ap-name</i> ]	Displays SSID policy configuration on an access point.
<b>show wireless client mac-address</b> <i>mac_address</i> <b>service-policy</b> { <b>input</b>   <b>output</b> }	Displays details of the client policy.
<b>show wlan qos service-policies</b>	Displays the SSID policies configured on all WLANs.
<b>show ap name</b> <i>ap_name</i> <b>service-policy</b>	Displays all the policies configured on the AP.

## Configuration Examples for QoS

### Examples: Classification by Access Control Lists

This example shows how to classify packets for QoS by using access control lists (ACLs):

```
Device# configure terminal
Device(config)# access-list 101 permit ip host 12.4.1.1 host 15.2.1.1
Device(config)# class-map acl-101
Device(config-cmap)# description match on access-list 101
```

```
Device(config-cmap)# match access-group 101
Device(config-cmap)#
```

After creating a class map by using an ACL, you then create a policy map for the class, and apply the policy map to an interface for QoS.

#### Related Topics

[Creating a Traffic Class \(CLI\)](#), on page 1365

[Class Maps](#), on page 1340

## Examples: Class of Service Layer 2 Classification

This example shows how to classify packets for QoS using a class of service Layer 2 classification:

```
Device# configure terminal
Device(config)# class-map cos
Device(config-cmap)# match cos ?
    <0-7> Enter up to 4 class-of-service values separated by white-spaces
Device(config-cmap)# match cos 3 4 5
Device(config-cmap)#
```

After creating a class map by using a CoS Layer 2 classification, you then create a policy map for the class, and apply the policy map to an interface for QoS.

## Examples: Class of Service DSCP Classification

This example shows how to classify packets for QoS using a class of service DSCP classification:

```
Device# configure terminal
Device(config)# class-map dscp
Device(config-cmap)# match dscp af21 af22 af23
Device(config-cmap)#
```

After creating a class map by using a DSCP classification, you then create a policy map for the class, and apply the policy map to an interface for QoS.

## Examples: VLAN ID Layer 2 Classification

This example shows how to classify for QoS using a VLAN ID Layer 2 classification:

```
Device# configure terminal
Device(config)# class-map vlan-120
Device(config-cmap)# match vlan ?
    <1-4095> VLAN id
Device(config-cmap)# match vlan 120
Device(config-cmap)#
```

After creating a class map by using a VLAN Layer 2 classification, you then create a policy map for the class, and apply the policy map to an interface for QoS.

## Examples: Classification by DSCP or Precedence Values

This example shows how to classify packets by using DSCP or precedence values:

```
Device# configure terminal
Device(config)# class-map prec2
Device(config-cmap)# description matching precedence 2 packets
Device(config-cmap)# match ip precedence 2
Device(config-cmap)# exit
Device(config)# class-map ef
Device(config-cmap)# description EF traffic
Device(config-cmap)# match ip dscp ef
Device(config-cmap)#
```

After creating a class map by using a DSCP or precedence values, you then create a policy map for the class, and apply the policy map to an interface for QoS.

## Examples: Hierarchical Classification

The following is an example of a hierarchical classification, where a class named parent is created, which matches another class named child. The class named child matches based on the IP precedence being set to 2.

```
Device# configure terminal
Device(config)# class-map child
Device(config-cmap)# match ip precedence 2
Device(config-cmap)# exit
Device(config)# class-map parent
Device(config-cmap)# match class child
Device(config-cmap)#
```

After creating the parent class map, you then create a policy map for the class, and apply the policy map to an interface for QoS.

### Related Topics

[Hierarchical QoS](#), on page 1332

## Examples: Hierarchical Policy Configuration

The following is an example of a configuration using hierarchical policies:

```
Device# configure terminal
Device(config)# class-map c1
Device(config-cmap)# match dscp 30
Device(config-cmap)# exit

Device(config)# class-map c2
Device(config-cmap)# match precedence 4
Device(config-cmap)# exit

Device(config)# class-map c3
Device(config-cmap)# exit

Device(config)# policy-map child
```

```

Device(config-pmap)# class c1
Device(config-pmap-c)# priority level 1
Device(config-pmap-c)# police rate percent 20 conform-action transmit exceed action drop
Device(config-pmap-c-police)# exit
Device(config-pmap-c)# exit

Device(config-pmap)# class c2
Device(config-pmap-c)# bandwidth 20000
Device(config-pmap-c)# exit
Device(config-pmap)# class class-default
Device(config-pmap-c)# bandwidth 20000
Device(config-pmap-c)# exit
Device(config-pmap)# exit
Device(config-pmap)# exit

Device(config)# policy-map parent
Device(config-pmap)# class class-default
Device(config-pmap-c)# shape average 1000000
Device(config-pmap-c)# service-policy child
Device(config-pmap-c)# end

```

The following example shows a hierarchical policy using table maps:

```

Device(config)# table-map dscp2dscp
  Device(config-tablemap)# default copy
Device(config)# table-map dscp2up
Device(config-tablemap)# map from 46 to 6
Device(config-tablemap)# map from 34 to 5
Device(config-tablemap)# default copy
Device(config)# policy-map ssid_child_policy
Device(config-pmap)# class voice
Device(config-pmap-c)# priority level 1
Device(config-pmap-c)# police 15000000
Device(config-pmap)# class video
Device(config-pmap-c)# priority level 2
Device(config-pmap-c)# police 10000000
Device(config)# policy-map ssid_policy
Device(config-pmap)# class class-default
Device(config-pmap-c)# shape average 30000000
Device(config-pmap-c)# queue-buffer ratio 0
Device(config-pmap-c)# set dscp dscp table dscp2dscp
Device(config-pmap-c)# service-policy ssid_child_policy

```

### Related Topics

[Hierarchical QoS](#), on page 1332

## Examples: Classification for Voice and Video

This example describes how to classify packet streams for voice and video using device specific information.

In this example, voice and video are coming in from end-point A into GigabitEthernet1/0/1 on the device and have precedence values of 5 and 6, respectively. Additionally, voice and video are also coming from end-point B into GigabitEthernet1/0/2 on the device with DSCP values of EF and AF11, respectively.

Assume that all the packets from the both the interfaces are sent on the uplink interface, and there is a requirement to police voice to 100 Mbps and video to 150 Mbps.

To classify per the above requirements, a class to match voice packets coming in on GigabitEthernet1/0/1 is created, named voice-interface-1, which matches precedence 5. Similarly another class for voice is created, named voice-interface-2, which will match voice packets in GigabitEthernet1/0/2. These classes are associated

to two separate policies named input-interface-1, which is attached to GigabitEthernet1/0/1, and input-interface-2, which is attached to GigabitEthernet1/0/2. The action for this class is to mark the qos-group to 10. To match packets with QoS-group 10 on the output interface, a class named voice is created which matches on QoS-group 10. This is then associated to another policy named output-interface, which is associated to the uplink interface. Video is handled in the same way, but matches on QoS-group 20.

The following example shows how classify using the above device specific information:

```

Device(config)#
Device(config)# class-map voice-interface-1
Device(config-cmap)# match ip precedence 5
Device(config-cmap)# exit

Device(config)# class-map video-interface-1
Device(config-cmap)# match ip precedence 6
Device(config-cmap)# exit

Device(config)# class-map voice-interface-2
Device(config-cmap)# match ip dscp ef
Device(config-cmap)# exit

Device(config)# class-map video-interface-2
Device(config-cmap)# match ip dscp af11
Device(config-cmap)# exit

Device(config)# policy-map input-interface-1
Device(config-pmap)# class voice-interface-1
Device(config-pmap-c)# set qos-group 10
Device(config-pmap-c)# exit

Device(config-pmap)# class video-interface-1
Device(config-pmap-c)# set qos-group 20

Device(config-pmap-c)# policy-map input-interface-2
Device(config-pmap)# class voice-interface-2
Device(config-pmap-c)# set qos-group 10
Device(config-pmap-c)# class video-interface-2
Device(config-pmap-c)# set qos-group 20
Device(config-pmap-c)# exit
Device(config-pmap)# exit

Device(config)# class-map voice
Device(config-cmap)# match qos-group 10
Device(config-cmap)# exit

Device(config)# class-map video
Device(config-cmap)# match qos-group 20

Device(config)# policy-map output-interface
Device(config-pmap)# class voice
Device(config-pmap-c)# police 256000 conform-action transmit exceed-action drop
Device(config-pmap-c-police)# exit
Device(config-pmap-c)# exit

Device(config-pmap)# class video
Device(config-pmap-c)# police 1024000 conform-action transmit exceed-action drop
Device(config-pmap-c-police)# exit
Device(config-pmap-c)# exit

```



## Examples: Wireless QoS Policy Classified by Voice, Video, and Multicast Traffic

The following example provides a template for creating a port child policy for managing quality of service for voice and video traffic.

```
Policy-map port_child_policy
  Class voice (match dscp ef)
    Priority level 1
    Police Multicast Policer
  Class video (match dscp af41)
    Priority level 2
    Police Multicast Policer
  Class mcast-data (match non-client-nrt)
    Bandwidth remaining ratio <>
  Class class-default (NRT Data)
    Bandwidth remaining ratio <>
```



**Note** Multicast Policer in the example above is not a keyword. It refers to the policing policy configured.

Two class maps with name voice and video are configured with DSCP assignments of 46 and 34. The voice traffic is assigned the priority of 1 and the video traffic is assigned the priority level 2 and is processed using Q0 and Q1. If your network receives multicast voice and video traffic, you can configure multicast policers. The non-client NRT data and NRT data are processed using the Q2 and Q3 queues.

### Related Topics

- [Port Policies](#), on page 1329
- [Port Policy Format](#), on page 1329
- [Wireless QoS Multicast](#), on page 1343

## Examples: Configuring Downstream SSID Policy

To configure a downstream BSSID policy, you must first configure a port child policy with priority level queuing.

Type of Policy	Example
User-defined port child policy	<pre>policy-map port_child_policy   class voice     priority level 1 20000    class video     priority level 2 10000    class non-client-nrt-class     bandwidth remaining ratio 10    class class-default     bandwidth remaining ratio 15</pre>

Type of Policy	Example
Egress BSSID policy	<pre> policy-map bssid-policer   queue-buffer ratio 0   class class-default     shape average 30000000   set dscp dscp table dscp2dscp   set wlan user-priority dscp table dscp2up   service-policy ssid_child_qos </pre>
SSID Child QoS policy	<pre> Policy Map ssid-child_qos   Class voice     priority level 1     police cir 5m     admit cac wmm-tspec       UP 6,7 / tells WCM allow 'voice'   TSPEC\SIP snoop for this ssid     rate 4000 / must be police rate   value is in kbps)   Class video     priority level 2     police cir 60000 </pre>

**Related Topics**

[Applying an SSID or Client Policy on a WLAN \(CLI\)](#), on page 1380

[SSID Policies](#), on page 1331

## Examples: Ingress SSID Policies

The following examples show ingress SSID hierarchical policies:

Type of ingress SSID policies	Example
Ingress SSID hierarchical policies	<pre> policy-map ssid-child-policy class voice //match dscp 46 police 3m class video //match dscp 34 police 4m policy-map ssid-in-policy class class-default set dscp wlan user-priority table up2dscp service-policy ssid-child-policy </pre>
	<pre> policy-map ssid_in_policy class dscp-40 set cos 1 police 10m class up-1 set dscp 34 police 12m class dscp-10 set dscp 20 police 15m class class-default set dscp wlan user-priority table up2dscp police 50m </pre>

## Examples: Client Policies

Type of Client Policy	Example/Details
Default egress client policy	<p>Any incoming traffic contains the user-priority as 0.</p> <p><b>Note</b> The default client policy is enabled only on WMM clients that are ACM-enabled.</p> <p>You can verify if ACM is enabled by using the <b>show ap dot11 5ghz network</b> command. To enable ACM, use the <b>ap dot11 5ghz cac voice acm</b> command.</p> <pre> Policy-map client-def-down class class-default set wlan user-priority 0 </pre>
Default ingress client policy	<p>Any traffic that is sent to the wired network from wireless network will result in the DSCP value being set to 0.</p> <p><b>Note</b> The default client policy is enabled only on WMM clients that are ACM-enabled.</p> <pre> Policy-map client-def-up class class-default set dscp 0 </pre>

Type of Client Policy	Example/Details
<p>Client policies generated automatically and applied to the WMM client when the client authenticates to a profile in AAA with a configured QoS-level attribute.</p>	<pre> Policy Map platinum-WMM Class voice-plat   set wlan user-priority 6 Class video-plat   set wlan user-priority 4 Class class-default   set wlan user-priority 0  Policy Map gold-WMM Class voice-gold   set wlan user-priority 4 Class video-gold   set wlan user-priority 4 Class class-default   set wlan user-priority 0 </pre>
<p>Non-WMM client precious metal policies</p>	<pre> Policy Map platinum   set wlan user-priority 6 </pre>
<p>Egress client policy where any traffic matching class voice1, the user priority is set to a pre-defined value.</p>	<p>The class can be set to assign a DSCP or ACL.</p> <pre> Policy Map client1-down Class voice1 //match dscp, cos   set wlan user-priority &lt;&gt; Class voice2 //match acl   set wlan user-priority &lt;&gt; Class voice3   set wlan user-priority &lt;&gt; Class class-default   set wlan user-priority 0 </pre>
<p>Client policy based on AAA and TCLAS</p>	<pre> Policy Map client2-down[ AAA+ TCLAS pol example] Class voice\\match dscp   police &lt;&gt;   set &lt;&gt; Class class-default   set &lt;&gt; Class voice1   voice2 [match acls]   police &lt;&gt;   class voice1     set &lt;&gt;   class voice2     set &lt;&gt; </pre>
<p>Client policy for voice and video for traffic in the egress direction</p>	<pre> Policy Map client3-down   class voice \\match dscp, cos     police X   class video     police Y   class class-default     police Z </pre>

Type of Client Policy	Example/Details
Client policy for voice and video for traffic in the ingress direction using policing	<pre>Policy Map client1-up   class voice    \\match dscp, up, cos     police X   class video     police Y   class class-default     police Z</pre>
Client policy for voice and video based on DSCP	<pre>Policy Map client2-up   class voice    \\match dscp, up, cos set dscp &lt;&gt;   class video     set dscp &lt;&gt;   class class-default     set dscp &lt;&gt;</pre>
Client ingress policy with marking and policing	<pre>policy-map client_in_policy class dscp-48 //match dscp 48   set cos 3   police 2m class up-4    //match wlan user-priority 4   set dscp 10   police 3m class acl    //match acl   set cos 2   police 5m class class-default   set dscp 20   police 15m</pre>
Hierarchical client ingress policy	<pre>policy-map client-child-policy class voice //match dscp 46 set dscp 40 police 5m class video //match dscp 34 set dscp 30 police 7m policy-map client-in-policy class class-default police 15m service-policy client-child-policy</pre>

**Related Topics**

[Configuring Client Policies \(CLI\)](#)

[Client Policies](#), on page 1331

## Examples: Average Rate Shaping Configuration

The following example shows how to configure average rate shaping:

```
Device# configure terminal
Device(config)# class-map precl
```

```

Device(config-cmap) # description matching precedence 1 packets
Device(config-cmap) # match ip precedence 1
Device(config-cmap) # end

Device# configure terminal
Device(config) # class-map prec2
Device(config-cmap) # description matching precedence 2 packets
Device(config-cmap) # match ip precedence 2
Device(config-cmap) # exit

Device(config) # policy-map shaper
Device(config-pmap) # class prec1
Device(config-pmap-c) # shape average 512000
Device(config-pmap-c) # exit

Device(config-pmap) # policy-map shaper
Device(config-pmap) # class prec2
Device(config-pmap-c) # shape average 512000
Device(config-pmap-c) # exit

Device(config-pmap) # class class-default
Device(config-pmap-c) # shape average 1024000

```

After configuring the class maps, policy map, and shape averages for your configuration, proceed to then apply the policy map to the interface for QoS.

#### Related Topics

[Configuring Shaping \(CLI\)](#), on page 1409

[Average Rate Shaping](#), on page 1348

## Examples: Queue-limit Configuration

The following example shows how to configure a queue-limit policy based upon DSCP values and percentages:

```

Device# configure terminal
Device#(config) # policy-map port-queue
Device#(config-pmap) # class dscp-1-2-3
Device#(config-pmap-c) # bandwidth percent 20
Device#(config-pmap-c) # queue-limit dscp 1 percent 80
Device#(config-pmap-c) # queue-limit dscp 2 percent 90
Device#(config-pmap-c) # queue-limit dscp 3 percent 100
Device#(config-pmap-c) # exit

Device#(config-pmap) # class dscp-4-5-6
Device#(config-pmap-c) # bandwidth percent 20
Device#(config-pmap-c) # queue-limit dscp 4 percent 20
Device#(config-pmap-c) # queue-limit dscp 5 percent 30
Device#(config-pmap-c) # queue-limit dscp 6 percent 20
Device#(config-pmap-c) # exit

Device#(config-pmap) # class dscp-7-8-9
Device#(config-pmap-c) # bandwidth percent 20
Device#(config-pmap-c) # queue-limit dscp 7 percent 20
Device#(config-pmap-c) # queue-limit dscp 8 percent 30
Device#(config-pmap-c) # queue-limit dscp 9 percent 20
Device#(config-pmap-c) # exit

Device#(config-pmap) # class dscp-10-11-12
Device#(config-pmap-c) # bandwidth percent 20

```

```

Device# (config-pmap-c) # queue-limit dscp 10 percent 20
Device# (config-pmap-c) # queue-limit dscp 11 percent 30
Device# (config-pmap-c) # queue-limit dscp 12 percent 20
Device# (config-pmap-c) # exit

Device# (config-pmap) # class dscp-13-14-15
Device# (config-pmap-c) # bandwidth percent 10
Device# (config-pmap-c) # queue-limit dscp 13 percent 20
Device# (config-pmap-c) # queue-limit dscp 14 percent 30
Device# (config-pmap-c) # queue-limit dscp 15 percent 20
Device# (config-pmap-c) # end
Device#

```

After finishing with the above policy map queue-limit configuration, you can then proceed to apply the policy map to an interface for QoS.

#### Related Topics

[Configuring Queue Limits \(CLI\)](#), on page 1406

[Weighted Tail Drop](#), on page 1351

## Examples: Queue Buffers Configuration

The following example shows how configure a queue buffer policy and then apply it to an interface for QoS:

```

Device# configure terminal
Device(config)# policy-map policy1001
Device(config-pmap)# class class1001
Device(config-pmap-c)# bandwidth remaining ratio 10
Device(config-pmap-c)# queue-buffer ratio ?
<0-100> Queue-buffers ratio limit
Device(config-pmap-c)# queue-buffer ratio 20
Device(config-pmap-c)# end

Device# configure terminal
Device(config)# interface gigabitEthernet2/0/3
Device(config-if)# service-policy output policy1001
Device(config-if)# end

```

#### Related Topics

[Configuring Queue Buffers \(CLI\)](#), on page 1404

[Queue Buffer Allocation](#), on page 1353

## Examples: Policing Action Configuration

The following example displays the various policing actions that can be associated to the policer. These actions are accomplished using the conforming, exceeding, or violating packet configurations. You have the flexibility to drop, mark and transmit, or transmit packets that have exceeded or violated a traffic profile.

For example, a common deployment scenario is one where the enterprise customer polices traffic exiting the network towards the service provider and marks the conforming, exceeding and violating packets with different DSCP values. The service provider could then choose to drop the packets marked with the exceeded and violated DSCP values under cases of congestion, but may choose to transmit them when bandwidth is available.



**Note** The Layer 2 fields can be marked to include the CoS fields, and the Layer 3 fields can be marked to include the precedence and the DSCP fields.

One useful feature is the ability to associate multiple actions with an event. For example, you could set the precedence bit and the CoS for all conforming packets. A submode for an action configuration could then be provided by the policing feature.

This is an example of a policing action configuration:

```
Device# configure terminal
Device(config)# policy-map police
Device(config-pmap)# class class-default
Device(config-pmap-c)# police cir 1000000 pir 2000000
Device(config-pmap-c-police)# conform-action transmit
Device(config-pmap-c-police)# exceed-action set-dscp-transmit dscp table exceed-markdown-table
Device(config-pmap-c-police)# violate-action set-dscp-transmit dscp table
violate-markdown-table
Device(config-pmap-c-police)# end
```

In this example, the exceed-markdown-table and violate-mark-down-table are table maps.



**Note** Policer-based markdown actions are only supported using table maps. Only one markdown table map is allowed for each marking field in the device.

#### Related Topics

[Configuring Police \(CLI\)](#), on page 1399

[Policing](#), on page 1343

## Examples: Policer VLAN Configuration

The following example displays a VLAN policer configuration. At the end of this configuration, the VLAN policy map is applied to an interface for QoS.

```
Device# configure terminal
Device(config)# class-map vlan100
Device(config-cmap)# match vlan 100
Device(config-cmap)# exit
Device(config)# policy-map vlan100
Device(config-pmap)# policy-map class vlan100
Device(config-pmap-c)# police 100000 bc conform-action transmit exceed-action drop
Device(config-pmap-c-police)# end
Device# configure terminal
Device(config)# interface gigabitEthernet1/0/5
Device(config-if)# service-policy input vlan100
```

#### Related Topics

[Classifying, Policing, and Marking Traffic on SVIs by Using Policy Maps \(CLI\)](#), on page 1384

[Policy Map on VLANs](#), on page 1342



## Examples: Policing Units

The policing unit is the basis on which the token bucket works. CIR and PIR are specified in bits per second. The burst parameters are specified in bytes. This is the default mode; it is the unit that is assumed when no units are specified. The CIR and PIR can also be configured in percent, in which case the burst parameters have to be configured in milliseconds.

The following is an example of a policer configuration in bits per second. In this configuration, a dual-rate three-color policer is configured where the units of measurement is bits. The burst and peak burst are all specified in bits.

```
Device(config)# policy-map bps-policer
Device(config-pmap)# class class-default
Device(config-pmap-c)# police rate 100000 peak-rate 1000000
conform-action transmit exceed-action set-dscp-transmit
dscp table DSCP_EXCE violate-action drop
```

## Examples: Single-Rate Two-Color Policing Configuration

The following example shows how to configure a single-rate two-color policer:

```
Device(config)# class-map match-any precl
Device(config-cmap)# match ip precedence 1
Device(config-cmap)# exit
Device(config)# policy-map policer
Device(config-pmap)# class precl
Device(config-pmap-c)# police cir 256000 conform-action transmit exceed-action drop
Device(config-pmap-c-police)# exit
Device(config-pmap-c)#
```

### Related Topics

[Configuring Police \(CLI\)](#), on page 1399

[Single-Rate Two-Color Policing](#), on page 1347

## Examples: Dual-Rate Three-Color Policing Configuration

The following example shows how to configure a dual-rate three-color policer:

```
Device# configure terminal
Device(config)# policy-Map dual-rate-3color-policer
Device(config-pmap)# class class-default
Device(config-pmap-c)# police cir 64000 bc 2000 pir 128000 be 2000
Device(config-pmap-c-police)# conform-action transmit
Device(config-pmap-c-police)# exceed-action set-dscp-transmit dscp table exceed-markdown-table
Device(config-pmap-c-police)# violate-action set-dscp-transmit dscp table
violate-markdown-table
Device(config-pmap-c-police)# exit
Device(config-pmap-c)#
```

In this example, the exceed-markdown-table and violate-mark-down-table are table maps.



**Note** Policer based markdown actions are only supported using table maps. Only one markdown table map is allowed for each marking field in the device.

### Related Topics

[Configuring Police \(CLI\)](#), on page 1399

[Dual-Rate Three-Color Policing](#), on page 1347

## Examples: Table Map Marking Configuration

The following steps and examples show how to use table map marking for your QoS configuration:

### 1. Define the table map.

Define the table-map using the **table-map** command and indicate the mapping of the values. This table does not know of the policies or classes within which it will be used. The default command in the table map indicates the value to be copied into the ‘to’ field when there is no matching ‘from’ field. In the example, a table map named table-map1 is created. The mapping defined is to convert the value from 0 to 1 and from 2 to 3, while setting the default value to 4.

```
Device(config)# table-map table-map1
Device(config-tablemap)# map from 0 to 1
Device(config-tablemap)# map from 2 to 3
Device(config-tablemap)# default 4
Device(config-tablemap)# exit
```

### 2. Define the policy map where the table map will be used.

In the example, the incoming CoS is mapped to the DSCP based on the mapping specified in the table table-map1. For this example, if the incoming packet has a DSCP of 0, the CoS in the packet is set 1. If no table map name is specified the command assumes a default behavior where the value is copied as is from the ‘from’ field (DSCP in this case) to the ‘to’ field (CoS in this case). Note however, that while the CoS is a 3-bit field, the DSCP is a 6-bit field, which implies that the CoS is copied to the first three bits in the DSCP.

```
Device(config)# policy map policy1
Device(config-pmap)# class class-default
Device(config-pmap-c)# set cos dscp table table-map1
Device(config-pmap-c)# exit
```

### 3. Associate the policy to an interface.

```
Device(config)# interface GigabitEthernet1/0/1
Device(config-if)# service-policy output policy1
Device(config-if)# exit
```

### Related Topics

[Configuring Table Maps \(CLI\)](#), on page 1387

[Table Map Marking](#), on page 1345

## Example: Table Map Configuration to Retain CoS Markings

The following example shows how to use table maps to retain CoS markings on an interface for your QoS configuration.

The `cos-trust-policy` policy (configured in the example) is enabled in the ingress direction to retain the CoS marking coming into the interface. If the policy is not enabled, only the DSCP is trusted by default. If a pure Layer 2 packet arrives at the interface, then the CoS value will be rewritten to 0 when there is no such policy in the ingress port for CoS.

```
Device# configure terminal
Device(config)# table-map cos2cos
Device(config-tablemap)# default copy
Device(config-tablemap)# exit

Device(config)# policy map cos-trust-policy
Device(config-pmap)# class class-default
Device(config-pmap-c)# set cos cos table cos2cos
Device(config-pmap-c)# exit

Device(config)# interface GigabitEthernet1/0/2
Device(config-if)# service-policy input cos-trust-policy
Device(config-if)# exit
```

### Related Topics

[Trust Behavior for Wired and Wireless Ports](#), on page 1354

## Where to Go Next

Review the auto-QoS documentation to see if you can use these automated capabilities for your QoS configuration.

## Additional References for QoS

### Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	<i>QoS Command Reference (Catalyst 3850 Switches)</i> <i>Cisco IOS Quality of Service Solutions Command Reference</i>
Call Admission Control (CAC)	<i>System Management Configuration Guide (Catalyst 3850 Switches)</i> <i>System Management Command Reference (Catalyst 3850 Switches)</i>
Multicast Shaping and Policing Rate	<i>IP Multicast Routing Configuration Guide (Catalyst 3850 Switches)</i>

Related Topic	Document Title
Application Visibility and Control	<i>System Management Configuration Guide (Catalyst 3850 Switches)</i> <i>System Management Command Reference (Catalyst 3850 Switches)</i>
Application Visibility and Control	<i>System Management Configuration Guide (Catalyst 3850 Switches)</i> <i>System Management Command Reference (Catalyst 3850 Switches)</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### Standards and RFCs

Standard/RFC	Title
—	

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for QoS

Release	Modification
Cisco IOS XE 3.3SE	This feature was introduced.
Cisco IOS XE 3.3SE	<p>Consistent system default trust behavior for both wired and wireless ports.</p> <p>The Cisco IOS XE 3.2 Release supported different trust defaults for wired and wireless ports. The trust default for wired ports was the same as for this software release. For wireless ports, the default system behavior was non-trust, which meant that when the came up, all markings for the wireless ports were defaulted to zero and no traffic received priority treatment. For compatibility with an existing wired , all traffic went to the best-effort queue by default. The access point performed priority queuing by default.</p> <p>The default trust behavior in the case of wireless ports could be changed by using the <b>no qos wireless default untrust</b> command.</p>
Cisco IOS XE 3.3SE	<p>Support for IPv6 wireless clients.</p> <p>The Cisco IOS XE 3.2 software release did not support IPv6 for wireless clients. This is now supported. Client policies can now have IPv4 and IPv6 filters.</p>
Cisco IOS XE 3.3SE	Support for 3 radios and 11ac.
Cisco IOS XE 3.3SE	<p>New classification counters available in the <b>show policy-map</b> command.</p> <p><b>Note</b> This feature is only available on wired targets.</p>

Release	Modification
Cisco IOS XE 3.6E	Marking and policing actions for ingress SSID policies. Client policies are applied at the access point.
Cisco IOS XE 3.6E	New classification counters for wireless targets available in the <b>show policy-map</b> command.
Cisco IOS XE 3.6E	Statistics are supported only for ingress policies.



## PART **XV**

# Radio Resource Management

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## CHAPTER 84

# Radio Resource Management

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## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Configuring Radio Resource Management

The device should be configured as a mobility controller and not a mobility anchor to configure Radio Resource Management. It may require dynamic channel assignment functionality for the home APs to be supported.

The new mobility architecture that involves mobility controller and mobility agent must be configured on the switch or controllers for RRM to work.



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**Note** Refer Mobility Configuration Guide for configuring mobility controller and mobility agent.

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# Restrictions for Radio Resource Management

The number of APs in a RF-group is limited to 500.

If an AP tries to join the RF-group that already holds the maximum number of APs it can support, the device rejects the application and throws an error.

To enable Airtime Fairness mode for APs, you should disable enforce-policy mode and reapply it again. This will change the airtime fairness configuration for all the APs. You can also use the **ap name <ap-name> dot11 24ghz airtime-fairness mode enforce-policy** command to change airtime fairness mode for individual APs.

## Information About Radio Resource Management

The Radio Resource Management (RRM) software that is embedded in the device acts as a built-in Radio Frequency (RF) engineer to consistently provide real-time RF management of your wireless network. RRM enables devices to continually monitor their associated lightweight access points for the following information:

- Traffic load—The total bandwidth used for transmitting and receiving traffic. It enables wireless LAN managers to track and plan network growth ahead of client demand.
- Interference—The amount of traffic coming from other 802.11 sources.
- Noise—The amount of non-802.11 traffic that is interfering with the currently assigned channel.
- Coverage—The Received Signal Strength (RSSI) and signal-to-noise ratio (SNR) for all connected clients.
- Other —The number of nearby access points.

RRM performs these functions:

- Radio resource monitoring
- Power control transmission
- Dynamic channel assignment
- Coverage hole detection and correction
- RF grouping



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**Note**

RRM grouping does not occur when an AP operates in a static channel that is not in the DCA channel list. The Neighbor Discovery Protocol (NDP) is sent only on DCA channels; therefore, when a radio operates on a non-DCA channel, it does not receive NDP on the channel.

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## Radio Resource Monitoring

RRM automatically detects and configures new devices and lightweight access points as they are added to the network. It then automatically adjusts the associated and nearby lightweight access points to optimize coverage and capacity.

Lightweight access points can scan all the valid channels for the country of operation as well as for channels available in other locations. The access points in local mode go *offchannel* for a period not greater than 60 ms to monitor these channels for noise and interference. Packets collected during this time are analyzed to detect rogue access points, rogue clients, ad-hoc clients, and interfering access points.



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**Note** In the presence of voice traffic or other critical traffic (in the last 100 ms), access points can defer off-channel measurements. The access points also defer off-channel measurements based on the WLAN scan priority configurations.

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Each access point spends only 0.2 percent of its time off channel. This activity is distributed across all the access points so that adjacent access points are not scanning at the same time, which could adversely affect wireless LAN performance.

RRM supports new mobility architecture for RF grouping that involves Mobility Controller (MC) and Mobility Agent (MA).

- Mobility Controller (MC)—The Cisco WLC 5700 Series Controllers, Cisco Catalyst 3850 Switch, or Cisco Unified Wireless Networking Solution controller can act as MC. The MC has MC functionality and MA functionality that is running internally into it.
- Mobility Agent (MA)—The Mobility Agent is the component that maintains client mobility state machine for a mobile client.

## Information About RF Groups

An RF group is a logical collection of controllers that coordinate to perform RRM in a globally optimized manner to perform network calculations on a per-radio basis. An RF group exists for each 802.11 network type. Clustering Cisco Catalyst 9800 Series Wireless Controller into a single RF group enables the RRM algorithms to scale beyond the capabilities of a single Cisco Catalyst 9800 Series Wireless Controller.

An RF group is created based on the following parameters:

- User-configured RF network name.
- Neighbor discovery performed at the radio level.
- Country list configured on MC.

RF grouping runs between MCs.

Lightweight access points periodically send out neighbor messages over the air. Access points using the same RF group name validate messages from each other.

When access points on different controllers hear validated neighbor messages at a signal strength of  $-80$  dBm or stronger, the controllers dynamically form an RF neighborhood in auto mode. In static mode, the leader is manually selected and the members are added to the RF Group. .



**Note** RF groups and mobility groups are similar, in that, they both define clusters of controllers, but they are different in terms of their use. An RF group facilitates scalable, system-wide dynamic RF management, while a mobility group facilitates scalable, system-wide mobility and controller redundancy.

## RF Group Leader

Starting in the 7.0.116.0 release, the RF Group Leader can be configured in two ways as follows:

- **Auto Mode**—In this mode, the members of an RF group elect an RF group leader to maintain a *master* power and channel scheme for the group. The RF grouping algorithm dynamically chooses the RF group leader and ensures that an RF group leader is always present. Group leader assignments can and do change (for instance, if the current RF group leader becomes inoperable or RF group members experience major changes).
- **Static Mode**—In this mode, a user selects a controller as an RF group leader manually. In this mode, the leader and the members are manually configured and fixed. If the members are unable to join the RF group, the reason is indicated. The leader tries to establish a connection with a member every minute if the member has not joined in the previous attempt.

The RF group leader analyzes real-time radio data collected by the system, calculates the power and channel assignments, and sends them to each of the controllers in the RF group. The RRM algorithms ensure system-wide stability, and restrain channel and power scheme changes to the appropriate local RF neighborhoods.

In Cisco WLC software releases prior to 6.0, the dynamic channel assignment (DCA) search algorithm attempts to find a good channel plan for the radios associated to Cisco WLCs in the RF group, but it does not adopt a new channel plan unless it is considerably better than the current plan. The channel metric of the worst radio in both plans determines which plan is adopted. Using the worst-performing radio as the single criterion for adopting a new channel plan can result in pinning or cascading problems.

Pinning occurs when the algorithm could find a better channel plan for some of the radios in an RF group, but is prevented from pursuing such a channel plan change because the worst radio in the network does not have any better channel options. The worst radio in the RF group could potentially prevent other radios in the group from seeking better channel plans. The larger the network, the more likely pinning becomes.

Cascading occurs when one radio's channel change results in successive channel changes to optimize the remaining radios in the RF neighborhood. Optimizing these radios could lead to their neighbors and their neighbors' neighbors having a suboptimal channel plan and triggering their channel optimization. This effect could propagate across multiple floors or even multiple buildings if all the access point radios belong to the same RF group. This change results in considerable client confusion and network instability.

The main cause of both pinning and cascading is the way in which the search for a new channel plan is performed and that any potential channel plan changes are controlled by the RF circumstances of a single radio. In Cisco WLC software release 6.0, the DCA algorithm has been redesigned to prevent both pinning and cascading. The following changes have been implemented:

- **Multiple local searches**—The DCA search algorithm performs multiple local searches initiated by different radios in the same DCA run rather than performing a single global search that is driven by a single radio. This change addresses both pinning and cascading, while maintaining the desired flexibility and adaptability of DCA and without jeopardizing stability.

- Multiple Channel Plan Change Initiators (CPCIs)—Previously, the single worst radio was the sole initiator of a channel plan change. Now each radio in an RF group is evaluated and prioritized as a potential initiator. Intelligent randomization of the resulting list ensures that every radio is eventually evaluated, which eliminates the potential for pinning.
- Limiting the propagation of channel plan changes (Localization)—For each CPCI radio, the DCA algorithm performs a local search for a better channel plan, but only the CPCI radio itself and its one-hop neighboring access points are actually allowed to change their current transmit channels. The impact of an access point triggering a channel plan change is felt only to within two RF hops from that access point, and the actual channel plan changes are confined to within a one-hop RF neighborhood. Because this limitation applies across all CPCI radios, cascading cannot occur.
- Non-RSSI-based cumulative cost metric—A cumulative cost metric measures how well an entire region, neighborhood, or network performs with respect to a given channel plan. The individual cost metrics of all the access points in that area are considered in order to provide an overall understanding of the channel plan's quality. These metrics ensure that the improvement or deterioration of each single radio is factored into any channel plan change. The objective is to prevent channel plan changes in which a single radio improves, but at the expense of multiple other radios experiencing a considerable performance decline.

The RRM algorithms run at a specified updated interval, which is 600 seconds by default. Between update intervals, the RF group leader sends keepalive messages to each of the RF group members and collects real-time RF data.



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**Note** Several monitoring intervals are also available. See the Configuring RRM section for details.

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## RF Group Name

A controller is configured in an RF group name, which is sent to all the access points joined to the controller and used by the access points as the shared secret for generating the hashed MIC in the neighbor messages. To create an RF group, you configure all of the controllers to be included in the group with the same RF group name.

If there is any possibility that an access point joined to a controller might hear RF transmissions from an access point on a different controller, you should configure the controller with the same RF group name. If RF transmissions between access points can be heard, then system-wide RRM is recommended to avoid 802.11 interference and contention as much as possible.

## Mobility Controller

An MC can either be a group leader or a group member. One of the MCs can act as a RF group leader based on RF grouping and RF group election with other MCs. The order of priority to elect the RF leader is based on the maximum number of APs the controller or switch can support. The highest priority being 1 and the least being 5.

1. WiSM 2 Controllers
2. Cisco WLC 5700 Series Controllers
3. WiSM 1 Controllers
4. Catalyst 3850 Series Switches
5. Catalyst 3650 Series Switches

When one of the MCs becomes the RRM group leader, the remaining MCs become RRM group members. RRM group members send their RF information to the Group Leader. The group leader determines a channel and Tx power plan for the network and passes the information back to the RF group members. The MCs push the power plan to MA for the radios that belong to MA. These channel and power plans are ultimately pushed down to individual radios.




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**Note** MC has MA functionality within it.

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## Mobility Agent

The MA communicates with the MC. The MC includes MAC or IP address of the switch/controller while communicating with the MA.

The MA provides the following information when polled by the MC:

- Interference or noise data.
- Neighbor data.
- Radio capabilities (supported channels, power levels).
- Radio configuration (power, channel, channel width).
- Radar data.

The MC exchanges the following information with the switch/controller (MA). The message includes:

- Configurations (channel/power/channel width) for individual radios.
- Polling requests for current configurations and RF measurements for individual radios
- Group Leader Update

In turn, the MA communicates the following messages with the MC:

- RF measurements from radios (e.g. load, noise and neighbor information)
- RF capabilities and configurations of individual radios

The MA sets channel, power, and channel width on the radios when directed by the MC. The DFS, coverage hole detection/mitigation, static channel/power configurations are performed by the MA.

## Rogue Access Point Detection in RF Groups

After you have created an RF group of controller, you need to configure the access points connected to the controller to detect rogue access points. The access points will then select the beacon or probe-response frames in neighboring access point messages to see if they contain an authentication information element (IE) that matches that of the RF group. If the selection is successful, the frames are authenticated. Otherwise, the authorized access point reports the neighboring access point as a rogue, records its BSSID in a rogue table, and sends the table to the controller.

## Transmit Power Control

The device dynamically controls access point transmit power based on the real-time wireless LAN conditions.

The Transmit Power Control (TPC) algorithm increases and decreases an access point's power in response to changes in the RF environment. In most instances, TPC seeks to lower an access point's power to reduce interference, but in the case of a sudden change in the RF coverage, for example, if an access point fails or becomes disabled, TPC can also increase power on the surrounding access points. This feature is different from coverage hole detection, which is primarily concerned with clients. TPC provides enough RF power to achieve the required coverage levels while avoiding channel interference between access points.

## Overriding the TPC Algorithm with Minimum and Maximum Transmit Power Settings

The TPC algorithm balances RF power in many diverse RF environments. However, it is possible that automatic power control will not be able to resolve some scenarios in which an adequate RF design was not possible to implement due to architectural restrictions or site restrictions, for example, when all the access points must be mounted in a central hallway, placing the access points close together, but requiring coverage to the edge of the building.

In these scenarios, you can configure maximum and minimum transmit power limits to override TPC recommendations. The maximum and minimum TPC power settings apply to all the access points through RF profiles in a RF network.

To set the Maximum Power Level Assignment and Minimum Power Level Assignment, enter the maximum and minimum transmit power used by RRM in the fields in the **Tx Power Control** window. The range for these parameters is -10 to 30 dBm. The minimum value cannot be greater than the maximum value; the maximum value cannot be less than the minimum value.

If you configure a maximum transmit power, RRM does not allow any access point attached to the device to exceed this transmit power level (whether the power is set by RRM TPC or by coverage hole detection). For example, if you configure a maximum transmit power of 11 dBm, no access point will transmit above 11 dBm, unless the access point is configured manually.

## Dynamic Channel Assignment

Two adjacent access points on the same channel can cause either signal contention or signal collision. In a collision, data is not received by the access point. This functionality can become a problem, for example, when someone reading an e-mail in a café affects the performance of the access point in a neighboring business. Even though these are separate networks, someone sending traffic to the café on channel 1 can disrupt communication in an enterprise using the same channel. Devices can dynamically allocate access point channel assignments to avoid conflict and increase capacity and performance. Channels are *reused* to avoid wasting scarce RF resources. In other words, channel 1 is allocated to a different access point far from the café, which is more effective than not using channel 1 altogether.

The device's Dynamic Channel Assignment (DCA) capabilities are also useful in minimizing adjacent channel interference between access points. For example, two overlapping channels in the 802.11b/g band, such as 1 and 2, cannot simultaneously use 11 or 54 Mbps. By effectively reassigning channels, the device keeps adjacent channels that are separated.



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**Note** We recommend that you use only nonoverlapping channels (1, 6, 11, and so on).

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**Note** Channel change does not require you to shut down the radio.

---

The device examines a variety of real-time RF characteristics to efficiently handle channel assignments as follows:

- **Access point received energy**—The received signal strength measured between each access point and its nearby neighboring access points. Channels are optimized for the highest network capacity.
- **Noise**—Noise can limit signal quality at the client and access point. An increase in noise reduces the effective cell size and degrades user experience. By optimizing channels to avoid noise sources, the device can optimize coverage while maintaining system capacity. If a channel is unusable due to excessive noise, that channel can be avoided.
- **802.11 interference**—Interference is any 802.11 traffic that is not a part of your wireless LAN, including rogue access points and neighboring wireless networks. Lightweight access points constantly scan all the channels looking for sources of interference. If the amount of 802.11 interference exceeds a predefined configurable threshold (the default is 10 percent), the access point sends an alert to the device. Using the RRM algorithms, the device may then dynamically rearrange channel assignments to increase system performance in the presence of the interference. Such an adjustment could result in adjacent lightweight access points being on the same channel, but this setup is preferable to having the access points remain on a channel that is unusable due to an interfering foreign access point.

In addition, if other wireless networks are present, the device shifts the usage of channels to complement the other networks. For example, if one network is on channel 6, an adjacent wireless LAN is assigned to channel 1 or 11. This arrangement increases the capacity of the network by limiting the sharing of frequencies. If a channel has virtually no capacity remaining, the device may choose to avoid this channel. In huge deployments in which all nonoverlapping channels are occupied, the device does its best, but you must consider RF density when setting expectations.

- **Load and utilization**—When utilization monitoring is enabled, capacity calculations can consider that some access points are deployed in ways that carry more traffic than other access points, for example, a lobby versus an engineering area. The device can then assign channels to improve the access point that has performed the worst. The load is taken into account when changing the channel structure to minimize the impact on the clients that are currently in the wireless LAN. This metric keeps track of every access point's transmitted and received packet counts to determine how busy the access points are. New clients avoid an overloaded access point and associate to a new access point. This *Load and utilization* parameter is disabled by default.

The device combines this RF characteristic information with RRM algorithms to make system-wide decisions. Conflicting demands are resolved using soft-decision metrics that guarantee the best choice for minimizing network interference. The end result is optimal channel configuration in a three-dimensional space, where access points on the floor above and below play a major factor in an overall wireless LAN configuration.



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**Note** Radios using 40-MHz channels in the 2.4-GHz band or 80MHz channels are not supported by DCA.

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The RRM startup mode is invoked in the following conditions:

- In a single-device environment, the RRM startup mode is invoked after the device is upgraded and rebooted.
- In a multiple-device environment, the RRM startup mode is invoked after an RF Group leader is elected.

You can trigger the RRM startup mode from the CLI.

The RRM startup mode runs for 100 minutes (10 iterations at 10-minute intervals). The duration of the RRM startup mode is independent of the DCA interval, sensitivity, and network size. The startup mode consists of 10 DCA runs with high sensitivity (making channel changes easy and sensitive to the environment) to converge to a steady-state channel plan. After the startup mode is finished, DCA continues to run at the specified interval and sensitivity.



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**Note** DCA algorithm interval is set to 1 hour, but DCA algorithm always runs in default interval of 10 min, channel allocation occurs at 10-min intervals for the first 10 cycles, and channel changes occur as per the DCA algorithm every 10 min. After that the DCA algorithm goes back to the configured time interval. This is common for both DCA interval and anchor time because it follows the steady state.

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**Note** If Dynamic Channel Assignment (DCA)/Transmit Power Control (TPC) is turned off on the RF group member, and auto is set on RF group leader, the channel or TX power on a member gets changed as per the algorithm that is run on the RF group leader.

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## Coverage Hole Detection and Correction

The RRM coverage hole detection algorithm can detect areas of radio coverage in a wireless LAN that are below the level needed for robust radio performance. This feature can alert you to the need for an additional (or relocated) lightweight access point.

If clients on a lightweight access point are detected at threshold levels (RSSI, failed client count, percentage of failed packets, and number of failed packets) lower than those specified in the RRM configuration, the access point sends a “coverage hole” alert to the device. The alert indicates the existence of an area where clients are continually experiencing poor signal coverage, without having a viable access point to which to roam. The device discriminates between coverage holes that can and cannot be corrected. For coverage holes that can be corrected, the device mitigates the coverage hole by increasing the transmit power level for that specific access point. The device does not mitigate coverage holes caused by clients that are unable to increase their transmit power or are statically set to a power level because increasing their downstream transmit power might increase interference in the network.

# How to Configure RRM

## Configuring Advanced RRM CCX Parameters (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ap dot11 24ghz   5ghz rrm ccx location-measurement interval</b> <b>Example:</b> Device(config)# <code>ap dot11 24ghz rrm ccx location-measurement 15</code>	Configures the interval for 802.11 CCX client location measurements. The range is from 10 to 32400 seconds.
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring Neighbor Discovery Type (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ap dot11 24ghz   5ghz rrm ndp-type {protected   transparent}</b> <b>Example:</b> Device(config)# <code>ap dot11 24ghz rrm ndp-type protected</code> Device(config)# <code>ap dot11 24ghz rrm ndp-type transparent</code>	Configures the neighbor discovery type. By default, the mode is set to “transparent”. <ul style="list-style-type: none"> <li>• <b>protected</b>—Sets the neighbor discover type to protected. Packets are encrypted.</li> <li>• <b>transparent</b>—Sets the neighbor discover type to transparent. Packets are sent as is.</li> </ul>

	Command or Action	Purpose
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring RRM Profile Thresholds, Monitoring Channels, and Monitoring Intervals (GUI)

### Procedure

- Step 1** Choose **Configuration > Wireless > 802.11a/n/ac > RRM > General** or **Configuration > Wireless > 802.11b/g/n > RRM > General** to open RRM General page.
- Step 2** Configure profile thresholds used for alarming as follows:
- Note** The profile thresholds have no bearing on the functionality of the RRM algorithms. Devices send an SNMP trap (or an alert) to the Cisco Prime Infrastructure or another trap receiver when individual APs values set for these threshold parameters are exceeded.
- In the **Interference** text box, enter the percentage of interference (802.11 traffic from sources outside of your wireless network) on a single access point. The valid range is 0 to 100%, and the default value is 10%.
  - In the **Clients** text box, enter the number of clients on a single access point. The valid range is 1 to 75, and the default value is 12.
  - In the **Noise** text box, enter the level of noise (non-802.11 traffic) on a single access point. The valid range is -127 to 0 dBm, and the default value is -70 dBm.
  - In the **Utilization** text box, enter the percentage of RF bandwidth being used by a single access point. The valid range is 0 to 100%, and the default value is 80%.
  - In the **Throughput** text box, enter the level of Throughput being used by a single access point. The valid range is 1000 to 10000000, and the default value is 1000000.
- Step 3** From the **Channel List** drop-down list, choose one of the following options to specify the set of channels that the access point uses for RRM scanning:
- **All Channels**—RRM channel scanning occurs on all channels supported by the selected radio, which includes channels not allowed in the country of operation.
  - **Country Channels**—RRM channel scanning occurs only on the data channels in the country of operation. This is the default value.
  - **DCA Channels**—RRM channel scanning occurs only on the channel set used by the DCA algorithm, which by default includes all of the non-overlapping channels allowed in the country of operation. However, you can specify the channel set to be used by DCA if desired. To do so, follow instructions in the [Dynamic Channel Assignment](#).
- Step 4** Configure monitor intervals as follows:
- In the **Channel Scan Interval** text box, enter (in seconds) the sum of the time between scans for each channel within a radio band. The entire scanning process takes 50 ms per channel, per radio and runs at

the interval configured here. The time spent listening on each channel is determined by the non-configurable 50-ms scan time and the number of channels to be scanned. For example, in the U.S. all 11 802.11b/g channels are scanned for 50 ms each within the default 180-second interval. So every 16 seconds, 50 ms is spent listening on each scanned channel ( $180/11 = \sim 16$  seconds). The Channel Scan Interval parameter determines the interval at which the scanning occurs. The valid range is 60 to 3600 seconds, and the default value for 802.11a/n/ac and 802.11b/g/n radios is 180 seconds.

- b. In the **Neighbor Packet Frequency** text box, enter (in seconds) how frequently neighbor packets (messages) are sent, which eventually builds the neighbor list. The valid range is 60 to 3600 seconds, and the default value is 60 seconds.

**Note** If the access point radio does not receive a neighbor packet from an existing neighbor within 60 minutes, the Cisco WLC deletes that neighbor from the neighbor list.

**Step 5** Click **Apply**.

**Step 6** Click **Save Configuration**.

**Note** Click **Set to Factory Default** if you want to return all of the Cisco WLC's RRM parameters to their factory-default values.

## Configuring RF Groups

This section describes how to configure RF groups through either the GUI or the CLI.



**Note** The RF group name is generally set at deployment time through the Startup Wizard. However, you can change it as necessary.



**Note** When the multiple-country feature is being used, all controllers intended to join the same RF group must be configured with the same set of countries, configured in the same order.



**Note** You can also configure RF groups using the Cisco Prime Infrastructure.



**Note** In Auto mode, RF group leader will skip TPC and DCA for first three runs of grouping cycle in order to stabilize the RF-group

## Configuring the RF Group Mode (GUI)

### Procedure

- 
- Step 1** Choose **Configuration > Wireless > 802.11a/n/ac > RRM > RF Grouping** or **Configuration > Wireless > 802.11b/g/n > RRM > RF Grouping** to open the RF Grouping page.
- Step 2** From the **Group Mode** drop-down list, choose the mode that you want to configure for this Cisco WLC.
- You can configure RF grouping in the following modes:
- auto—Sets the RF group selection to automatic update mode.
    - Note** A configured static leader cannot become a member of another RF group until its mode is set to “auto”.
  - leader—Sets the RF group selection to static mode, and sets this Cisco WLC as the group leader.
  - off—Sets the RF group selection off. Every Cisco WLC optimizes its own access point parameters.
    - Note** A Cisco WLC with a lower priority cannot assume the role of a group leader if a Cisco WLC with a higher priority is available. Here, priority is related to the processing power of the Cisco WLC.
    - Note** We recommend that Cisco WLCs participate in automatic RF grouping. You can override RRM settings without disabling automatic RF group participation.
- Step 3** Click **Apply** to save the configuration and click **Restart** to restart the RRM RF Grouping algorithm.
- Step 4** If you configured RF Grouping mode for this Cisco WLC as a static leader, you can add group members from the Group Members section as follows:
- a. In the device Name text box, enter the Cisco WLC that you want to add as a member to this group.
  - b. In the IP Address text box, enter the IP address of the Cisco WLC.
  - c. Click **Add** to add the member to this group.
    - Note** If the member has not joined the static leader, the reason of the failure is shown in parentheses.
- Step 5** Click **Apply**.
- Step 6** Click **Save Configuration**.
- 

## Configuring RF Group Selection Mode (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

## Configuring an RF Group Name (CLI)

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 2</b>	<p><code>ap dot11 24ghz   5ghz rrm group-mode {auto   leader   off}</code></p> <p><b>Example:</b></p> <pre>Device(config)#ap dot11 24ghz rrm group-mode leader</pre>	<p>Configures RF group selection mode for 802.11 bands.</p> <ul style="list-style-type: none"> <li>• <b>auto</b>—Sets the 802.11 RF group selection to automatic update mode.</li> <li>• <b>leader</b>—Sets the 802.11 RF group selection to leader mode.</li> <li>• <b>off</b>—Disables the 802.11 RF group selection.</li> </ul>
<b>Step 3</b>	<p><code>end</code></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	<p>Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.</p>

## Configuring an RF Group Name (CLI)

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><code>configure terminal</code></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	<p>Enters global configuration mode.</p>
<b>Step 2</b>	<p><code>wireless rf-network name</code></p> <p><b>Example:</b></p> <pre>Device (config)# wireless rf-network test1</pre>	<p>Creates an RF group. The group name should be ASCII String up to 19 characters and is case sensitive.</p> <p><b>Note</b> Repeat this procedure for each controller that you want to include in the RF group.</p>
<b>Step 3</b>	<p><code>end</code></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	<p>Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.</p>
<b>Step 4</b>	<p><code>show network profile profile_number</code></p>	<p>Displays the RF group.</p> <p><b>Note</b> You can view the network profile number from 1 to 4294967295.</p>

## Configuring an RF Group Name (GUI)

### Procedure

- 
- Step 1** Choose **Configuration > Controller > General** to open the General page.
  - Step 2** Enter a name for the RF group in the RF Group Name text box. The name can contain up to 19 ASCII characters and is case sensitive.
  - Step 3** Click **Apply** to commit your changes.
  - Step 4** Click **Save Configuration** to save your changes.
  - Step 5** Repeat this procedure for each controller that you want to include in the RF group.
- 

## Configuring Members in an 802.11 Static RF Group (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ap dot11 24ghz   5ghz rrm group-member group_name ip_addr</b>  <b>Example:</b> Device(config)# <code>ap dot11 24ghz rrm group-member Grpmem01 10.1.1.1</code>	Configures members in a 802.11 static RF group. The group mode should be set as leader for the group member to be active.
<b>Step 3</b>	<b>end</b>  <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring Transmit Power Control

### Configuring the Tx-Power Control Threshold (CLI)

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>ap dot11 24ghz   5ghz rrm tpc-threshold</b> <i>threshold_value</i>  <b>Example:</b>  Device(config)# <b>ap dot11 24ghz rrm</b> <b>tpc-threshold -60</b>	Configures the Tx-power control threshold used by RRM for auto power assignment. The range is from -80 to -50.
<b>Step 3</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring the Tx-Power Level (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>ap dot11 24ghz   5ghz rrm</b> <b>txpower</b> { <i>trans_power_level</i>   <b>auto</b>   <b>max</b>   <b>min</b>   <b>once</b> }  <b>Example:</b>  Device(config)# <b>ap dot11 24ghz rrm txpower</b> <b>auto</b>	Configures the 802.11 tx-power level <ul style="list-style-type: none"> <li>• <b>trans_power_level</b>—Sets the transmit power level.</li> <li>• <b>auto</b>—Enables auto-RF.</li> <li>• <b>max</b>—Configures the maximum auto-RF tx-power.</li> <li>• <b>min</b>—Configures the minimum auto-RF tx-power.</li> <li>• <b>once</b>—Enables one-time auto-RF.</li> </ul>
<b>Step 3</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring Transmit Power Control (GUI)

### Procedure

- Step 1** Choose **Configuration > Wireless > 802.11a/n/ac > RRM > TPC** or **Configuration > Wireless > 802.11b > RRM > TPC** to open RRM Tx Power Control (TPC) page.



**Step 2** Choose the Transmit Power Control.

Coverage Optimal Mode (TPCv1)— Offers strong signal coverage and stability. In this mode, power can be kept low to gain extra capacity and reduce interference.

**Step 3** Choose one of the following options from the Power Level Assignment Method list to specify the Cisco WLC's dynamic power assignment mode:

- **Automatic**—Causes the Cisco WLC to periodically evaluate and, if necessary, update the transmit power for all joined access points. This is the default value.
- **On Demand**—Causes the Cisco WLC to periodically evaluate the transmit power for all joined access points. However, the Cisco WLC updates the power, if necessary, only when you click **Apply** after choosing **On Demand**.

**Note** The Cisco WLC does not evaluate and update the transmit power immediately when you click **Apply** after choosing **On Demand**. It waits for the next 600-second interval. This value is not configurable.

- **Fixed**—Prevents the Cisco WLC from evaluating and, if necessary, updating the transmit power for joined access points. The power level is set to the fixed value chosen from the drop-down list. The corresponding option for **Fixed** when you try to configure from CLI is **once**.

**Note** The transmit power level is assigned an integer value instead of a value in mW or dBm. The integer corresponds to a power level that varies depending on the regulatory domain, channel, and antennas in which the access points are deployed.

**Note** For optimal performance, we recommend that you use the Automatic setting.

**Step 4** Enter the maximum and minimum power level assignment values in the Maximum Power Level Assignment and Minimum Power Level Assignment text boxes.

The range for the Maximum Power Level Assignment is –10 to 30 dBm.

The range for the Minimum Power Level Assignment is –10 to 30 dBm.

**Step 5** In the Power Threshold text box, enter the cutoff signal level used by RRM when determining whether to reduce an access point's power. The default value for this parameter is –70 dBm for TPCv1, but can be changed when access points are transmitting at higher (or lower) than desired power levels.

The range for this parameter is –80 to –50 dBm. Increasing this value (between –65 and –50 dBm) causes the access points to operate at a higher transmit power. Decreasing the value has the opposite effect.

In applications with a dense population of access points, it may be useful to decrease the threshold to –80 or –75 dBm to reduce the number of BSSIDs (access points) and beacons seen by the wireless clients. Some wireless clients might have difficulty processing a large number of BSSIDs or a high beacon rate and might exhibit problematic behavior with the default threshold.

This page also shows the following nonconfigurable transmit power level parameter settings:

- **Power Neighbor Count**—The minimum number of neighbors an access point must have for the transmit power control algorithm to run.
- **Power Assignment Leader**—The MAC address of the RF group leader, which is responsible for power level assignment.
- **Last Power Level Assignment**—The last time RRM evaluated the current transmit power level assignments.

- Step 6** Click **Apply**.
- Step 7** Click **Save Configuration**.

## Configuring 802.11 RRM Parameters

### Configuring Advanced 802.11 Channel Assignment Parameters (CLI)

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ap dot11 {24ghz   5ghz} rrm channel cleanair-event sensitivity {high   low   medium}</b>  <b>Example:</b> Device (config) # <code>ap dot11 24ghz rrm channel cleanair-event sensitivity high</code>	Configures CleanAir event-driven RRM parameters. <ul style="list-style-type: none"> <li>• <b>High</b>—Specifies the most sensitivity to non-Wi-Fi interference as indicated by the air quality (AQ) value.</li> <li>• <b>Low</b>—Specifies the least sensitivity to non-Wi-Fi interference as indicated by the AQ value.</li> <li>• <b>Medium</b>—Specifies medium sensitivity to non-Wi-Fi interference as indicated by the AQ value.</li> </ul>
<b>Step 3</b>	<b>ap dot11 {24ghz   5ghz} rrm channel dca {channel number   anchor-time   global {auto   once}   interval   min-metric   sensitivity {high   low   medium}}</b>  <b>Example:</b> Device (config) # <code>ap dot11 24ghz rrm channel dca interval 2</code>	Configures Dynamic Channel Assignment (DCA) algorithm parameters for the 802.11 band. <ul style="list-style-type: none"> <li>• <b>&lt;I-14&gt;</b>—Enter a channel number to be added to the DCA list.</li> <li>• <b>anchor-time</b>—Configures the anchor time for the DCA. The range is between 0 and 23 hours.</li> <li>• <b>global</b>—Configures the DCA mode for all 802.11 Cisco APs.               <ul style="list-style-type: none"> <li>• <b>auto</b>—Enables auto-RF.</li> <li>• <b>once</b>—Enables auto-RF only once.</li> </ul> </li> <li>• <b>interval</b>—Configures the DCA interval value. The values are 1, 2, 3, 4, 6, 8, 12</li> </ul>

	Command or Action	Purpose
		<p>and 24 hours and the default value 0 denotes 10 minutes.</p> <ul style="list-style-type: none"> <li>• <b>min-metric</b>—Configures the DCA minimum RSSI energy metric. The range is between -100 and -60.</li> <li>• <b>sensitivity</b>—Configures the DCA sensitivity level to changes in the environment. <ul style="list-style-type: none"> <li>• <b>high</b>—Specifies the most sensitivity.</li> <li>• <b>low</b>—Specifies the least sensitivity.</li> <li>• <b>medium</b>—Specifies medium sensitivity.</li> </ul> </li> </ul>
<b>Step 4</b>	<p><b>ap dot11 5ghz rrm channel dca chan-width</b> {20   40   80   160   best maximum {20   40   80   MAX}}</p> <p><b>Example:</b></p> <pre>Device(config)#ap dot11 5ghz rrm channel dca chan-width best maximum 20</pre>	Configures the DCA channel bandwidth for all 802.11 radios in the 5-GHz band. Sets the channel bandwidth to 20 MHz, 40 MHz, or 80 MHz, or Best; 20 MHz is the default value for channel bandwidth. 80 MHz is the default value for best. Set the channel bandwidth to best before configuring the constraints.
<b>Step 5</b>	<p><b>ap dot11 {24ghz   5ghz} rrm channel device</b></p> <p><b>Example:</b></p> <pre>Device(config)#ap dot11 24ghz rrm channel device</pre>	Configures the persistent non-Wi-Fi device avoidance in the 802.11 channel assignment.
<b>Step 6</b>	<p><b>ap dot11 {24ghz   5ghz} rrm channel foreign</b></p> <p><b>Example:</b></p> <pre>Device(config)#ap dot11 24ghz rrm channel foreign</pre>	Configures the foreign AP 802.11 interference avoidance in the channel assignment.
<b>Step 7</b>	<p><b>ap dot11 {24ghz   5ghz} rrm channel load</b></p> <p><b>Example:</b></p> <pre>Device(config)#ap dot11 24ghz rrm channel load</pre>	Configures the Cisco AP 802.11 load avoidance in the channel assignment.
<b>Step 8</b>	<p><b>ap dot11 {24ghz   5ghz} rrm channel noise</b></p> <p><b>Example:</b></p> <pre>Device(config)#ap dot11 24ghz rrm channel noise</pre>	Configures the 802.11 noise avoidance in the channel assignment.

	Command or Action	Purpose
<b>Step 9</b>	<b>end</b>  <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring Dynamic Channel Assignment (GUI)

You can specify the channels that the Dynamic Channel Assignment (DCA) algorithm considers when selecting the channels to be used for RRM scanning by using the Cisco WLC GUI.



**Note** This functionality is helpful when you know that the clients do not support certain channels because they are legacy devices or they have certain regulatory restrictions.

### Procedure

- Step 1** Disable the 802.11a/n/ac or 802.11b/g/n network as follows:
- Choose **Configuration > Wireless > 802.11a/n/ac > Network** or **Configuration > Wireless > 802.11b/g/n > Network** to open the Global Parameters page.
  - Unselect the **802.11a/n/ac** (or **802.11b/g/n**) **Network Status** check box.
  - Click **Apply**.
- Step 2** Choose **Configuration > Wireless > 802.11a/n/ac > RRM > DCA** or **Configuration > Wireless > 802.11b/g/n > RRM > DCA** to open the Dynamic Channel Assignment (DCA) page.
- Step 3** Choose one of the following options from the **Channel Assignment Method** drop-down list to specify the Cisco WLC's DCA mode:
- **Automatic**—Causes the Cisco WLC to periodically evaluate and, if necessary, update the channel assignment for all joined access points. This is the default value.
  - **Freeze**—Causes the Cisco WLC to evaluate and update the channel assignment for all joined access points, if necessary, only when you click **Apply** after selecting the **Freeze** option.
 

**Note** The Cisco WLC does not evaluate and update the channel assignment immediately when you click **Apply** after selecting the **Freeze** option. It waits for the next interval to elapse.
  - **OFF**—Turns off DCA and sets all access point radios to the first channel of the band. If you choose this option, you must manually assign channels on all radios.
 

**Note** For optimal performance, we recommend that you use the Automatic setting.
- Step 4** From the Interval drop-down list, choose one of the following options to specify how often the DCA algorithm is allowed to run: **10 minutes**, **1 hour**, **2 hours**, **3 hours**, **4 hours**, **6 hours**, **8 hours**, **12 hours**, or **24 hours**. The default value is 10 minutes.
- Step 5** From the AnchorTime drop-down list, choose a number to specify the time of day when the DCA algorithm is to start. The options are numbers between 0 and 23 (inclusive) representing the hour of the day from 12:00 a.m. to 11:00 p.m.

**Step 6** From the **DCA Channel Sensitivity** drop-down list, choose one of the following options to specify how sensitive the DCA algorithm is to environmental changes such as signal, load, noise, and interference when determining whether to change channels:

- **Low**—The DCA algorithm is not particularly sensitive to environmental changes.
- **Medium**—The DCA algorithm is moderately sensitive to environmental changes.
- **High**—The DCA algorithm is highly sensitive to environmental changes.

The default value is Medium. The DCA sensitivity thresholds vary by radio band, as noted in the following table:

**Table 102: DCA Sensitivity Thresholds**

Option	2.4-GHz DCA Sensitivity Threshold	5-GHz DCA Sensitivity Threshold
High	5 dB	5 dB
Medium	10 dB	15 dB
Low	20 dB	20 dB

**Step 7** This page also shows the following nonconfigurable channel parameter settings:

- **Channel Assignment Leader**—The MAC address of the RF group leader, which is responsible for channel assignment.

**Step 8** In the DCA Channel List area, the DCA Channels text box shows the channels that are currently selected. To choose a channel, select its check box in the Select column. To exclude a channel, unselect its check box.

The ranges are as follows:

- 802.11a—36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 132, 136, 140, 149, 153, 157, 161, 165 (depending on countries).
- 802.11b/g—1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 (depending on countries).

The defaults are as follows:

- 802.11a—36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 132, 136, 140, 149, 153, 157, 161
- 802.11b/g—1, 6, 11

**Step 9** Click **Apply**.

**Step 10** Reenable the 802.11 networks as follows:

- a. Choose **Configuration > Wireless > 802.11a/n/ac > Network** or **Configuration > Wireless > 802.11b/g/n > Network** to open the Global Parameters page.
- b. Select the **802.11a/n/ac** (or **802.11b/g/n**) **Network Status** check box.
- c. Click **Apply**.

**Step 11** Click **Save Configuration**.

## Configuring 802.11 Coverage Hole Detection (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ap dot11 24ghz   5ghz rrm coverage data {fail-percentage   packet-count   rssi-threshold}</b>  <b>Example:</b> Device(config)# <code>ap dot11 24ghz rrm coverage data fail-percentage 60</code>	Configures the 802.11 coverage hole detection for data packets. <ul style="list-style-type: none"> <li>• <b>fail-percentage</b>—Configures the 802.11 coverage failure-rate threshold for uplink data packets as a percentage that ranges from 1 to 100%.</li> <li>• <b>packet-count</b>—Configures the 802.11 coverage minimum failure count threshold for uplink data packets that ranges from 1 to 255.</li> <li>• <b>rssi-threshold</b>—Configures the 802.11 minimum receive coverage level for data packets that range from -90 to -60 dBm.</li> </ul>
<b>Step 3</b>	<b>ap dot11 24ghz   5ghz rrm coverage exception global <i>exception level</i></b>  <b>Example:</b> Device(config)# <code>ap dot11 24ghz rrm coverage exception global 50</code>	Configures the 802.11 Cisco AP coverage exception level as a percentage that ranges from 0 to 100%.
<b>Step 4</b>	<b>ap dot11 24ghz   5ghz rrm coverage level global <i>cli_min exception level</i></b>  <b>Example:</b> Device(config)# <code>ap dot11 24ghz rrm coverage level global 10</code>	Configures the 802.11 Cisco AP client minimum exception level that ranges from 1 to 75 clients.
<b>Step 5</b>	<b>ap dot11 24ghz   5ghz rrm coverage voice {fail-percentage   packet-count   rssi-threshold}</b>  <b>Example:</b> Device(config)# <code>ap dot11 24ghz rrm coverage voice packet-count 10</code>	Configures the 802.11 coverage hole detection for voice packets. <ul style="list-style-type: none"> <li>• <b>fail-percentage</b>—Configures the 802.11 coverage failure-rate threshold for uplink voice packets as a percentage that ranges from 1 to 100%.</li> <li>• <b>packet-count</b>—Configures the 802.11 coverage minimum failure count threshold for uplink voice packets that ranges from 1 to 255.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>rsi-threshold</b>—Configures the 802.11 minimum receive coverage level for voice packets that range from –90 to –60 dBm.</li> </ul>
<b>Step 6</b>	<b>end</b>  <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring Coverage Hole Detection (GUI)

### Procedure

- Step 1** Disable the 802.11 network as follows:
- Choose **Configuration > Wireless > 802.11a/n/ac** or **Configuration > Wireless > 802.11b/g/n** to open the 802.11a/n/ac (or 802.11b/g/n) Global Parameters page.
  - Unselect the **802.11a/n/ac** (or **802.11b/g/n**) **Network Status** check box.
  - Click **Apply**.
- Step 2** Choose **Configuration > Wireless > 802.11a/n/ac > RRM > Coverage Thresholds** or **Configuration > Wireless > 802.11b/g/n > RRM > Coverage Thresholds** to open coverage page.
- Step 3** Select the **Enable Coverage Hole Detection** check box to enable coverage hole detection, or unselect it to disable this feature. If you enable coverage hole detection, the Cisco WLC automatically determines, based on data received from the access points, if any access points have clients that are potentially located in areas with poor coverage. The default value is selected.
- Step 4** In the **Data RSSI** text box, enter the minimum Receive Signal Strength Indication (RSSI) value for data packets received by the access point. The value that you enter is used to identify coverage holes (or areas of poor coverage) within your network. If the access point receives a packet in the data queue with an RSSI value below the value that you enter here, a potential coverage hole has been detected. The valid range is –90 to –60 dBm, and the default value is –80 dBm. The access point takes data RSSI measurements every 5 seconds and reports them to the Cisco WLC in 90-second intervals.
- Step 5** In the **Voice RSSI** text box, enter the minimum Receive Signal Strength Indication (RSSI) value for voice packets received by the access point. The value that you enter is used to identify coverage holes within your network. If the access point receives a packet in the voice queue with an RSSI value below the value that you enter here, a potential coverage hole has been detected. The valid range is –90 to –60 dBm, and the default value is –80 dBm. The access point takes voice RSSI measurements every 5 seconds and reports them to the Cisco WLC in 90-second intervals.
- Step 6** In the **Min Failed Client Count per AP** text box, enter the minimum number of clients on an access point with an RSSI value at or below the data or voice RSSI threshold. The valid range is 1 to 75, and the default value is 3.
- Step 7** In the **Coverage Exception Level per AP** text box, enter the percentage of clients on an access point that are experiencing a low signal level but cannot roam to another access point. The valid range is 0 to 100%, and the default value is 25%.

**Note** If both the number and percentage of failed packets exceed the values configured for Failed Packet Count and Failed Packet Percentage (configurable through the Cisco WLC CLI) for a 5-second period, the client is considered to be in a pre-alarm condition. The Cisco WLC uses this information to distinguish between real and false coverage holes. False positives are generally due to the poor roaming logic implemented on most clients. A coverage hole is detected if both the number and percentage of failed clients meet or exceed the values entered in the Min Failed Client Count per AP and Coverage Exception Level per AP text boxes over two 90-second periods (a total of 180 seconds). The Cisco WLC determines if the coverage hole can be corrected and, if appropriate, mitigates the coverage hole by increasing the transmit power level for that specific access point.

**Step 8** Click **Apply**.

**Step 9** Reenable the 802.11 network as follows:

- Choose **Configuration > Wireless > 802.11a/n/ac > Network** or **Configuration > Wireless > 802.11b/g/n > Network** to open the 802.11a (or 802.11b/g) Global Parameters page.
- Select the **802.11a/n/ac** (or **802.11b/g/n**) **Network Status** check box.
- Click **Apply**.

**Step 10** Click **Save Configuration**.

## Configuring 802.11 Event Logging (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ap dot11 24ghz   5ghz rrm logging {channel   coverage   foreign   load   noise   performance   txpower}</b>  <b>Example:</b>  Device (config) # <code>ap dot11 24ghz rrm logging channel</code>  Device (config) # <code>ap dot11 24ghz rrm logging coverage</code>  Device (config) # <code>ap dot11 24ghz rrm logging foreign</code>  Device (config) # <code>ap dot11 24ghz rrm logging load</code>  Device (config) # <code>ap dot11 24ghz rrm logging noise</code>  Device (config) # <code>ap dot11 24ghz rrm logging performance</code>	Configures event-logging for various parameters. <ul style="list-style-type: none"> <li>• <b>channel</b>—Configures the 802.11 channel change logging mode.</li> <li>• <b>coverage</b>—Configures the 802.11 coverage profile logging mode.</li> <li>• <b>foreign</b>—Configures the 802.11 foreign interference profile logging mode.</li> <li>• <b>load</b>—Configures the 802.11 load profile logging mode.</li> <li>• <b>noise</b>—Configures the 802.11 noise profile logging mode.</li> <li>• <b>performance</b>—Configures the 802.11 performance profile logging mode.</li> <li>• <b>txpower</b>—Configures the 802.11 transmit power change logging mode.</li> </ul>



	Command or Action	Purpose
	<code>Device(config)#ap dot11 24ghz rrm logging txpower</code>	
<b>Step 3</b>	<b>end</b> <b>Example:</b> <code>Device(config)# end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring 802.11 Statistics Monitoring (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> <code>Device# configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ap dot11 24ghz   5ghz rrm monitor channel-list {all   country   dca}</b> <b>Example:</b> <code>Device(config)#ap dot11 24ghz rrm monitor channel-list all</code>	Sets the 802.11 monitoring channel-list for parameters such as noise/interference/roge. <ul style="list-style-type: none"> <li>• <b>all</b>— Monitors all channels.</li> <li>• <b>country</b>— Monitor channels used in configured country code.</li> <li>• <b>dca</b>— Monitor channels used by dynamic channel assignment.</li> </ul>
<b>Step 3</b>	<b>ap dot11 24ghz   5ghz rrm monitor coverage interval</b> <b>Example:</b> <code>Device(config)#ap dot11 24ghz rrm monitor coverage 600</code>	Configures the 802.11 coverage measurement interval in seconds that ranges from 60 to 3600.
<b>Step 4</b>	<b>ap dot11 24ghz   5ghz rrm monitor load interval</b> <b>Example:</b> <code>Device(config)#ap dot11 24ghz rrm monitor load 180</code>	Configures the 802.11 load measurement interval in seconds that ranges from 60 to 3600.
<b>Step 5</b>	<b>ap dot11 24ghz   5ghz rrm monitor noise interval</b> <b>Example:</b> <code>Device(config)#ap dot11 24ghz rrm monitor noise 360</code>	Configures the 802.11 noise measurement interval (channel scan interval) in seconds that ranges from 60 to 3600.

	Command or Action	Purpose
<b>Step 6</b>	<b>ap dot11 24ghz   5ghz rrm monitor signal interval</b> <b>Example:</b> Device(config)# <b>ap dot11 24ghz rrm monitor signal 480</b>	Configures the 802.11 signal measurement interval (neighbor packet frequency) in seconds that ranges from 60 to 3600.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring the 802.11 Performance Profile (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>ap dot11 24ghz   5ghz rrm profile clients cli_threshold_value</b> <b>Example:</b> Device(config)# <b>ap dot11 24ghz rrm profile clients 20</b>	Sets the threshold value for 802.11 Cisco AP clients that range between 1 and 75 clients.
<b>Step 3</b>	<b>ap dot11 24ghz   5ghz rrm profile foreign int_threshold_value</b> <b>Example:</b> Device(config)# <b>ap dot11 24ghz rrm profile foreign 50</b>	Sets the threshold value for 802.11 foreign interference that ranges between 0 and 100%.
<b>Step 4</b>	<b>ap dot11 24ghz   5ghz rrm profile noise for_noise_threshold_value</b> <b>Example:</b> Device(config)# <b>ap dot11 24ghz rrm profile noise -65</b>	Sets the threshold value for 802.11 foreign noise ranges between -127 and 0 dBm.
<b>Step 5</b>	<b>ap dot11 24ghz   5ghz rrm profile throughput throughput_threshold_value</b> <b>Example:</b>	Sets the threshold value for 802.11 Cisco AP throughput that ranges between 1000 and 10000000 bytes per second.

	Command or Action	Purpose
	Device(config)# <b>ap dot11 24ghz rrm profile throughput 10000</b>	
<b>Step 6</b>	<b>ap dot11 24ghz   5ghz rrm profile utilization rf_util_threshold_value</b>  <b>Example:</b>  Device(config)# <b>ap dot11 24ghz rrm profile utilization 75</b>	Sets the threshold value for 802.11 RF utilization that ranges between 0 to 100%.
<b>Step 7</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring Rogue Access Point Detection in RF Groups

### Configuring Rogue Access Point Detection in RF Groups (CLI)

#### Before you begin

Ensure that each controller in the RF group has been configured with the same RF group name.



**Note** The name is used to verify the authentication IE in all beacon frames. If the controller have different names, false alarms will occur.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>ap name <i>Cisco_AP</i> mode {local   monitor}</b>  <b>Example:</b>  Device# <b>ap name ap1 mode local</b>	Configures a particular access point for local (normal) mode or monitor (listen-only) mode. Perform this step for every access point connected to the controller. <ul style="list-style-type: none"> <li>• <b>monitor</b>— Sets the AP mode to monitor mode.</li> <li>• <b>clear</b>— Resets AP mode to local or remote based on the site.</li> <li>• <b>sensor</b>— Sets the AP mode to sensor mode.</li> <li>• <b>sniffer</b>— Sets the AP mode to wireless sniffer mode.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 3</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 4</b>	<b>wireless wps ap-authentication</b> <b>Example:</b> Device (config)# <b>wireless wps ap-authentication</b>	Enables rogue access point detection.
<b>Step 5</b>	<b>wireless wps ap-authentication threshold value</b> <b>Example:</b> Device (config)# <b>wireless wps ap-authentication threshold 50</b>	Specifies when a rogue access point alarm is generated. An alarm occurs when the threshold value (which specifies the number of access point frames with an invalid authentication IE) is met or exceeded within the detection period.  The valid threshold range is from 1 to 255, and the default threshold value is 1. To avoid false alarms, you may want to set the threshold to a higher value.  <b>Note</b> Enable rogue access point detection and threshold value on every controller in the RF group.  <b>Note</b> If rogue access point detection is not enabled on every controller in the RF group, the access points on the controller with this feature disabled are reported as rogues.

## Enabling Rogue Access Point Detection in RF Groups (GUI)

### Procedure

- 
- Step 1** Make sure that each Cisco WLC in the RF group has been configured with the same RF group name.
- Note** The name is used to verify the authentication IE in all beacon frames. If the Cisco WLCs have different names, false alarms will occur.
- Step 2** Choose **Configuration > Wireless > Access Points > All APs** to open the All APs page.
- Step 3** Click the name of an access point to open the All APs > Edit page.
- Step 4** Choose either **local** or **monitor** from the AP Mode drop-down list and click **Apply** to commit your changes.

- Step 5** Click **Save Configuration** to save your changes.
- Step 6** Repeat [Step 2](#) through [Step 5](#) for every access point connected to the Cisco WLC.
- Step 7** Choose **Configuration > Security > Wireless Protection Policies > AP Authentication/MFP** to open the AP Authentication Policy page.
- The name of the RF group to which this Cisco WLC belongs appears at the top of the page.
- Step 8** Choose **AP Authentication** from the Protection Type drop-down list to enable rogue access point detection.
- Step 9** Enter a number in the Alarm Trigger Threshold edit box to specify when a rogue access point alarm is generated. An alarm occurs when the threshold value (which specifies the number of access point frames with an invalid authentication IE) is met or exceeded within the detection period.
- Note** The valid threshold range is from 1 to 255, and the default threshold value is 1. To avoid false alarms, you may want to set the threshold to a higher value.
- Step 10** Click **Apply** to commit your changes.
- Step 11** Click **Save Configuration** to save your changes.
- Step 12** Repeat this procedure on every Cisco WLC in the RF group.
- Note** If rogue access point detection is not enabled on every Cisco WLC in the RF group, the access points on the Cisco WLCs with this feature disabled are reported as rogues.

## Monitoring RRM Parameters and RF Group Status

### Monitoring RRM Parameters

*Table 103: Commands for monitoring Radio Resource Management*

Commands	Description
show ap dot11 24ghz ccx	Displays the 802.11b CCX information for all Cisco APs.
show ap dot11 24ghz channel	Displays the configuration and statistics of the 802.11b channel assignment.
show ap dot11 24ghz coverage	Displays the configuration and statistics of the 802.11b coverage.
show ap dot11 24ghz group	Displays the configuration and statistics of the 802.11b grouping.
show ap dot11 24ghz l2roam	Displays 802.11b l2roam information.
show ap dot11 24ghz logging	Displays the configuration and statistics of the 802.11b event logging.
show ap dot11 24ghz monitor	Displays the configuration and statistics of the 802.11b monitoring.
show ap dot11 24ghz profile	Displays 802.11b profiling information for all Cisco APs.
show ap dot11 24ghz receiver	Displays the configuration and statistics of the 802.11b receiver.

Commands	Description
show ap dot11 24ghz summary	Displays the configuration and statistics of the 802.11b Cisco APs.
show ap dot11 24ghz txpower	Displays the configuration and statistics of the 802.11b transmit power control.
show ap dot11 5ghz ccx	Displays 802.11a CCX information for all Cisco APs.
show ap dot11 5ghz channel	Displays the configuration and statistics of the 802.11a channel assignment.
show ap dot11 5ghz coverage	Displays the configuration and statistics of the 802.11a coverage.
show ap dot11 5ghz group	Displays the configuration and statistics of the 802.11a grouping.
show ap dot11 5ghz l2roam	Displays 802.11a l2roam information.
show ap dot11 5ghz logging	Displays the configuration and statistics of the 802.11a event logging.
show ap dot11 5ghz monitor	Displays the configuration and statistics of the 802.11a monitoring.
show ap dot11 5ghz profile	Displays 802.11a profiling information for all Cisco APs.
show ap dot11 5ghz receiver	Displays the configuration and statistics of the 802.11a receiver.
show ap dot11 5ghz summary	Displays the configuration and statistics of the 802.11a Cisco APs.
show ap dot11 5ghz txpower	Displays the configuration and statistics of the 802.11a transmit power control.

## Verifying RF Group Status (CLI)

This section describes the new commands for RF group status.

The following commands can be used to verify RF group status on the .

**Table 104: Verifying Aggressive Load Balancing Command**

Command	Purpose
<b>show ap dot11 5ghz group</b>	Displays the controller name which is the RF group leader for the 802.11a RF network.
<b>show ap dot11 24ghz group</b>	Displays the controller name which is the RF group leader for the 802.11b/g RF network.

## Monitoring RF Group Status (GUI)

### Procedure

- Step 1** Choose **Configuration > Wireless > 802.11a/n > or 802.11b/g/n > RRM > RF Grouping** to open the RF Grouping Algorithm page.
- This page shows the details of the RF group, displaying the configurable parameter **Group mode**, the **Group role** of this Cisco WLC, the **Group Update Interval** and the Cisco WLC name and IP address of the **Group Leader** to this Cisco WLC.
- Note** RF grouping mode can be set using the **Group Mode** drop-down list.
- Tip Once a Cisco WLC has joined as a static member and you want to change the grouping mode, we recommend that you remove the member from the configured static-leader and also make sure that a member Cisco WLC has not been configured to be a member on multiple static leaders. This is to avoid repeated join attempts from one or more RF static leaders.
- Step 2** (Optional) Repeat this procedure for the network type that you did not select (802.11a/n or 802.11b/g/n).

## Examples: RF Group Configuration

This example shows how to configure RF group name:

```
Device# configure terminal
Device(config)# wireless rf-network test1
Device(config)# ap dot11 24ghz shutdown
Device(config)# end
Device # show network profile 5
```

This example shows how to configure rogue access point detection in RF groups:

```
Device# ap name ap1 mode local
Device# end
Device# configure terminal
Device(config)# wireless wps ap-authentication
Device(config)# wireless wps ap-authentication threshold 50
Device(config)# end
```

## Information About ED-RRM

Spontaneous interference is interference that appears suddenly on a network, perhaps jamming a channel or a range of channels completely. The Cisco CleanAir spectrum event-driven RRM feature allows you to set a threshold for air quality (AQ) that, if exceeded, triggers an immediate channel change for the affected access point. Most RF management systems can avoid interference, but this information takes time to propagate through the system. Cisco CleanAir relies on AQ measurements to continuously evaluate the spectrum and can trigger a move within 30 seconds. For example, if an access point detects interference from a video camera,

it can recover by changing channels within 30 seconds of the camera becoming active. Cisco CleanAir also identifies and locates the source of interference so that more permanent mitigation of the device can be performed at a later time.

## Configuring ED-RRM on the Cisco Wireless LAN Controller (CLI)

### Procedure

- 
- Step 1** Trigger spectrum event-driven radio resource management (RRM) to run when a Cisco CleanAir-enabled access point detects a significant level of interference by entering these commands:
- ap dot11 {24ghz | 5ghz} rrm channel cleanair-event**—Configures CleanAir driven RRM parameters for the 802.11 Cisco lightweight access points.
- ap dot11 {24ghz | 5ghz} rrm channel cleanair-event sensitivity {low | medium | high | custom}**—Configures CleanAir driven RRM sensitivity for the 802.11 Cisco lightweight access points. Default selection is Medium.
- ap dot11 {24ghz | 5ghz} rrm channel cleanair-event rogue-contribution**—Enables rogue contribution.
- ap dot11 {24ghz | 5ghz} rrm channel cleanair-event rogue-contribution duty-cycle thresholdvalue**—Configures threshold value for rogue contribution. The valid range is from 1 to 99, with 80 as the default.
- Step 2** Save your changes by entering this command:
- write memory**
- Step 3** See the CleanAir configuration for the 802.11a/n/ac or 802.11b/g/n network by entering this command:
- show ap dot11 {24ghz | 5ghz} cleanair config**
- Information similar to the following appears:

```
AdditionalClean Air Settings:
CleanAir Event-driven RRM State..... : Enabled
CleanAir Driven RRM Sensitivity..... : LOW
CleanAir Event-driven RRM Rogue Option..... : Enabled
CleanAir Event-driven RRM Rogue Duty Cycle... : 80
CleanAir Persistent Devices state..... : Disabled
CleanAir Persistent Device Propagation..... : Disabled
```

## Configuring ED-RRM (GUI)

### Procedure

- 
- Step 1** Choose **Configure > Radio Configurations > 2.4 GHZ or 5 GHZ > RRM > DCA** to open the ED-RRM page.



**Note** Before enabling ED-RRM, you have to disable Network Status from **Configure > Radio Configurations > 2.4 GHZ or 5 GHZ > Network > General** page, and then re-enable the network after configuring ED-RRM.

**Step 2** In the Event Driven RRM section, select the **EDRRM** check box to reveal ED-RRM parameters .

**Step 3** From the Sensitivity Threshold drop-down, select the value.

Options are: Low, Medium, or High. Default selection is Medium.

**Note** In the Show running configuration, the Sensitivity Threshold value selected by default is not visible.

**Step 4** Select the **Rogue Contribution** check box to reveal Rogue Duty-Cycle parameters .

**Step 5** Enter the **Rogue Duty Cycle** value in the text box.

The valid range is from 1 to 99, with 80 as the default.

**Step 6** Click **Apply**.

**Step 7** Click **Save Configuration**.

## Additional References for Radio Resource Management

### Related Documents

Related Topic	Document Title
RRM commands and their details	<i>RRM Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information For Performing Radio Resource Management Configuration

Release	Feature Information
Cisco IOS XE 3.3SE	This feature was introduced.



## CHAPTER 85

# Configuring XOR Slot for Cisco 2800/3800 Series Access Points

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- [Information About XOR Radio, on page 1469](#)
- [Configuring XOR Radio \(CLI\), on page 1469](#)
- [Monitoring XOR Radio Parameters, on page 1471](#)

## Information About XOR Radio

The Cisco Aironet 3800/2800 series access points are one of the 802.11ac Wave 2 supported APs.

In Cisco Aironet 2800/3800 series APs, slot 0 is an XOR radio that can be set up as a 2.4-GHz or 5-GHz or monitor radio. If it is a 2.4- or 5-GHz radio, it should support wireless clients to transmit and receive packets or voice or videos. It is the first time that an XOR radio supports transmission and reception, and behaves as a normal 2.4- or 5-GHz radio.

The Cisco Aironet 2800/3800 series APs with an XOR module supports the following modes:

- **Radio 0**—Is an XOR radio.
- **Radio 1**—Is a dedicated 5-GHz radio.

The Dual-Band (XOR) radio offers the ability to serve either the 2.4- or 5-GHz bands or passively monitor both bands on the same radio.

## Configuring XOR Radio (CLI)

- Enable an antenna on a given access point by entering this command:

```
ap name Cisco AP dot11 dual-band dot11 antenna {A | B | C | D}
```

```
ap name Cisco1 dot11 dual-band dot11 antenna A
```



---

**Note** To enable all antennas, enter the antenna values in the order as A -> B -> C -> D.

---

- Disable an antenna on a given access point by entering this command:

```
ap name Cisco AP no dot11 dual-band dot11 antenna {A | B | C | D}
```

```
ap name Cisco1 no dot11 dual-band dot11 antenna A
```




---

**Note** To disable all antennas, enter the antenna values in the order as D -> C -> B -> A.

---

- Configure the 802.11 dual-band external antenna gain for a given access point:

```
ap name Cisco AP dot11 dual-band antenna gain external antenna gain value
```

```
ap name Cisco1 dot11 dual-band antenna gain 4
```




---

**Note** **external antenna gain value**—Ranges from 0 to 40. Enter external antenna gain value in multiples of .5 dBi units (An integer value of 4 means 4 x 0.5 = 2 dBi of gain)

---

- Configure frequency band for a given access point:

```
ap name Cisco AP dot11 dual-band band {24ghz | 5ghz}
```

```
ap name Cisco1 dot11 dual-band band 5ghz
```

- Configure the channel width for a given access point:

```
ap name Cisco AP dot11 dual-band channel width {20 | 40 | 80 | 160}
```

```
ap name Cisco1 dot11 dual-band channel width 80
```

- Configure auto or custom channel number for a given access point:

```
ap name Cisco AP dot11 dual-band channel {channel number | auto}
```

- **channel number**—Ranges from 1 to 165.




---

**Note** If both radios are in the same band (5-GHz), you need to ensure that channels must be 100MHz apart.

---

- **auto**—Enable the auto channel assignment using the **auto** option.

```
ap name Cisco1 dot11 dual-band channel 2
```

- Enable CleanAir on a specified band for a given access point:

```
ap name Cisco AP dot11 dual-band cleanair band {24Ghz | 5Ghz}
```

```
ap name Cisco1 dot11 dual-band cleanair band 5Ghz
```

- Disable CleanAir on a specified band for a given access point:

```
ap name Cisco AP no dot11 dual-band cleanair band {24Ghz | 5Ghz}
```

```
ap name Cisco1 no dot11 dual-band cleanair band 5Ghz
```

- Disable the dual-band radio for a given access point:

```
ap name Cisco AP dot11 dual-band shutdown
```

```
ap name Cisco1 dot11 dual-band shutdown
```

- Enable the dual-band radio for a given access point:

```
ap name Cisco AP no dot11 dual-band shutdown
```

```
ap name Cisco1 no dot11 dual-band shutdown
```

- Configure the role of the dual-band radio for a given access point:

```
ap name Cisco AP dot11 dual-band role {auto | manual {client-serving | monitor}}
```

- **auto**—Switch to automatic radio role selection.
- **manual**—Switch to manual radio role selection.
- **client-serving**—Switch to client-serving role.
- **monitor**—Switch to monitor role.

```
ap name Cisco1 dot11 dual-band role manual client-serving
```

- Configure auto or custom transmit power level for a given access point:

```
ap name Cisco AP dot11 dual-band txpower {txpower_level | auto}
```

```
ap name Cisco1 dot11 dual-band txpower 2
```




---

**Note** `txpower_level`—Ranges from 1 to 8.

---

## Monitoring XOR Radio Parameters

*Table 105: Commands for monitoring XOR radio*

Commands	Description
show ap name <i>Cisco AP</i> config dot11 dual-band	Displays the detailed information on all dual-band radios on the given access point.
show ap name <i>Cisco AP</i> auto-rf dot11 dual-band	Displays the Auto-RF information for a given access point.
show ap name <i>Cisco AP</i> wlan dot11 dual-band	Displays the WLAN information for a given access point.

Commands	Description
show ap config dot11 dual-band summary	Displays the list of access points that have dual-band radio.



## CHAPTER 86

# Configuring Flexible Radio Assignment for Cisco 2800/3800 Series Access Points

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- [Information About Flexible Radio Assignment \(FRA\), on page 1473](#)
- [Coverage Overlap Factor \(COF\), on page 1474](#)
- [Radio Role Assignment, on page 1474](#)
- [Client Network Preference, on page 1475](#)
- [Steady State Operations, on page 1475](#)
- [FRA and Dual 5-GHz Operations, on page 1475](#)
- [Configuring Flexible Radio Assignment \(CLI\), on page 1476](#)
- [Monitoring Flexible Radio Assignment \(CLI\), on page 1477](#)
- [Configuring Client Network Preference \(CLI\), on page 1477](#)
- [Resetting Flexible Radio Assignment \(CLI\), on page 1477](#)
- [Configuring Micro or Macro Mode \(CLI\), on page 1478](#)
- [Monitoring Macro or Micro Transition Thresholds \(CLI\), on page 1478](#)
- [Configuring Probe Suppression \(CLI\), on page 1479](#)
- [Debugging Flexible Radio Assignment \(CLI\), on page 1480](#)

## Information About Flexible Radio Assignment (FRA)

Flexible Radio Assignment (FRA) is a new core algorithm added to RRM to analyze the NDP measurements and manage the hardware used to determine the role of a new dual-band radio (2.4-GHz, 5-GHz, or Monitor) in your network.

FRA performs the following:

- Calculates and maintains a measurement of redundancy for 2.4-GHz radios and represents this as a new measurement metric called Coverage Overlap Factor (COF).
- Manages the radio role assignment or re-assignment of XOR radios that are marked as redundant.

The FRA is tightly integrated into the existing RRM to run on mixed environments with legacy APs. You will need to know few new naming conventions and behaviors to understand the new operations. The existing AP MODE concept requires some modification. The Mode selection sets the entire AP (slot0 and slot1) into one of many operating modes including:

- Local Mode

- Monitor Mode
- Sniffer Mode

With the addition of dual-band (XOR) radio in slot0, you now have the ability to operate a single radio interface in many of the previous modes. There is no longer a need to place the entire AP into a MODE. When we apply this concept at the single radio level, this is called as a ROLE. The following are the two roles that can be assigned at the product release:

- Client Serving—Either 2.4-GHz or 5-GHz.
- Monitor—Monitor role.




---

**Note** Here, Client Serving is the same as the Local MODE, wherein, the radio supports clients in the selected band.

Points to remember:

A MODE—Is assigned to the whole AP (slot0/1).

A ROLE—Is assigned to a single radio interface (slot0).

---

## Coverage Overlap Factor (COF)

Let us discuss in detail about how the FRA calculates the Coverage Overlap Factor (COF) and what it does.

The FRA evaluates a coverage of 2.4-GHz only and determines if there is an overlapping coverage that creates interference. By default, the Cisco Aironet 3800/2800 Series APs initialize the 1\*2.4-GHz interface and 1\*5-GHz interface, which is the same as the Legacy AP. After the FRA completes the analysis, any 2.4-GHz XOR radio that is found to be redundant is assigned to a different and more beneficial role to support network goals.

The FRA uses the well-established Neighbor Discovery Protocol (NDP) output from RRM to locate each radio in RF distance and evaluates the overlapping coverage by cell. Using the NDP measurements from APs, the FRA plots the x and y co-ordinates relative to every other AP contained in the solution set (AP Group, physical neighbors). The circumference of each cell is calculated based on the present transmit power level of each AP. This produces a logical matrix of the coverage intersections for the AP.

A radio is marked as redundant when the calculated coverage meets or exceeds the FRA sensitivity threshold:

- **Low**—100% COF
- **Medium**—95% COF
- **High**—90% COF

For more information about COF, see the Radio Resource Management whitepaper.

## Radio Role Assignment

Once a radio is marked as redundant, the radio configuration determines the next step. The dual-band radio can be assigned to two operational states, namely:



- **Auto**—Is the default state. Once a dual-band radio is marked as redundant, the DCA helps in deciding the role that needs to be assigned to a radio.
- **Manual**—During the manual state, the FRA still produces a COF for the radio. However, you have complete control over assigning radios manually.

For more information about Radio Role Assignment, see the Radio Resource Management whitepaper.

## Client Network Preference

Client network preference allows you to characterize how you want to prioritize the behaviors of RRM. FRA has an entry here.

Let us see what happens when clients connected to 2.4-GHz interface is changed to 5-GHz interface. There are three options, out of which the FRA uses the Connectivity setting by default.

The three options are as follows:

- **Connectivity**—Preference on Connectivity.
- **Default**—No Client Network Preference Applied.
- **Throughput**—Preference on Throughput.

A radio returns to 2.4-GHz unless reverted (through CLI) or manually configured from the GUI or CLI.

For more information about Client Network Preference, see the Radio Resource Management whitepaper.

## Steady State Operations

FRA is designed to evaluate and remediate the over population in 2.4-GHz spectrum. If you are designing a network to optimize 5-GHz, you will have redundant 2.4-GHz interfaces. FRA manages the selection, transition, and assignment of redundant radios.

If the network design and number of APs are not changed, FRA does not have much to do other than monitoring. You cannot see the COF for APs not available in 2.4-GHz role. However, the role selection and DCA remains active. This means that, if you add APs or change the bandwidth you are serving, the FRA may choose a different role for your dual-band radio, if 5-GHz is assigned. It becomes challenging to keep that many interfaces in the air peacefully. You may view a 5-GHz interface switch to Monitor mode. You can lock down the radios by changing them to Manual and prevent the FRA from taking any more action.

But if you do this, you could also create issues when making changes as it might alter the balance of the spectrum, such as, bandwidth changes; which must always be treated as a major upgrade.

Thus, the COF becomes unavailable after some time for any flexible interface excluding the 2.4-GHz role.

## FRA and Dual 5-GHz Operations

The two modes of operation for a dual 5-GHz access points are as follows:

- **Micro or Macro**—A large cell with a smaller cell internal creating double the capacity within boundaries of a single cell.

- **Macro or Macro**—Dual independent 5-GHz cells doubling the coverage of a single traditional Dual-Band access point.

Micro or Macro modes of operation is applicable to the Cisco Aironet 2800/3800 Series I Model APs only. The antennas on this AP are designed to support a Cell within a Cell deployment.

The FRA and DCA enforces a minimum of 100MHz channel separation (frequency diversity) when operating as a dual 5-GHz Micro or Macro.

FRA also monitors two cells. You can move or transition clients between Micro and Macro cells using the following three methods:

- 802.11v BSS Transition
- 802.11k
- Probe Suppression

For more information on the 802.11v BSS Transition, 802.11k, and Probe Suppression, see the Radio Resource Management whitepaper.

## Configuring Flexible Radio Assignment (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ap fra {interval   sensitivity {high   low   medium}}</b>  <b>Example:</b> Device(config)# <code>ap fra interval 2</code>	Configures FRA on all Cisco access points. <ul style="list-style-type: none"> <li>• <b>interval</b>—Configures the FRA interval in hours. The range is from 1 to 24 hours. The default value is 1 Hour.</li> <li>• <b>sensitivity</b>—Configures the FRA sensitivity level. <ul style="list-style-type: none"> <li>• <b>high</b>—Specifies the most sensitivity.</li> <li>• <b>low</b>—Specifies the least sensitivity.</li> <li>• <b>medium</b>—Specifies the medium sensitivity.</li> </ul> </li> </ul>
<b>Step 3</b>	<b>end</b>  <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Monitoring Flexible Radio Assignment (CLI)

Table 106: Command for monitoring Flexible Radio Assignment (FRA)

Command	Description
show ap fra	Displays the FRA configurations and overlap factor.

## Configuring Client Network Preference (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ap dot11 {24ghz   5ghz } client-network-preference {connectivity   throughput}</b>  <b>Example:</b> Device(config)# <code>ap dot11 24 client-network-preference connectivity</code>	Configures the client network preference. <ul style="list-style-type: none"> <li>• <b>connectivity</b>—Sets the preference on connectivity.</li> <li>• <b>throughput</b>—Sets the preference on throughput.</li> </ul>
<b>Step 3</b>	<b>end</b>  <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Resetting Flexible Radio Assignment (CLI)

- Revert radios by entering this command:

```
ap fra revert {all {auto | static}| auto-only {auto | static}}
```

```
ap fra revert all auto
```

- **all**—Reverts all the XOR radios.
- **auto-only**—Reverts only the XOR radios currently in the automatic band selection.



**Note** If you have selected **all** or **auto-only** as the revert mode, you will need to select from either of these options as well, namely:

- **auto**—Places the XOR radios in the automatic band selection.
- **static**—Places the XOR radios in the static 2.4-GHz band.

## Configuring Micro or Macro Mode (CLI)

When the XOR radio in Cisco Aironet 2800/3800 I Series access point models is changed to operate in 5GHz band, the controller puts the slot0 to the lowest power level. Thus, forming the Micro or Macro cells.

Perform the following steps to configure Micro or Macro mode:

### Procedure

- 
- Step 1** Disable the dual-band radio on the Cisco access point by entering this command:  
**ap name *ap-name* dot11 dual-band shutdown**
- Step 2** If the radio is in **auto** or **manual** role, you must change it to **client-serving** role by entering this command:  
**ap name *ap-name* dot11 dual-band role manual client-serving**
- Step 3** Configure the operating band (5-GHz) by entering this command:  
**ap name *ap-name* dot11 dual-band band 5ghz**
- Step 4** Enable the dual-band radio on the Cisco access point by entering this command:  
**ap name *ap-name* no dot11 dual-band shutdown**
- 

## Monitoring Macro or Micro Transition Thresholds (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wireless macro-micro steering transition-threshold {balancing-window</b>	Configures Micro-Macro transition thresholds.

	Command or Action	Purpose
	<p><i>no_of_clients</i>  <b>client count</b> <i>no_of_clients</i>   <b>macro-to-micro</b> <i>RSSI_in_dBm</i>   <b>micro-to-macro</b> <i>RSSI_in_dBm</i> }</p> <p><b>Example:</b></p> <pre>Device(config)#wireless macro-micro steering transition-threshold balancing-window 1000</pre>	<ul style="list-style-type: none"> <li>• <b>balancing-window</b>—Configures the Micro-Macro client load balancing window. The <i>no_of_clients</i> value ranges from 0 to 65535.</li> <li>• <b>client</b>—Configures the Micro-Macro client parameters. The <i>no_of_clients</i> value ranges from 0 to 65535.</li> <li>• <b>macro-to-micro</b>—Configures the Macro to Micro transition RSSI. The <i>RSSI_in_dBm</i> value ranges from -128 to 0.</li> <li>• <b>micro-to-macro</b>—Configures the Micro to Macro transition RSSI. The <i>RSSI_in_dBm</i> value ranges from -128 to 0.</li> </ul>
<b>Step 3</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring Probe Suppression (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<p><b>wireless macro-micro steering probe-suppression</b> {<b>aggressiveness</b> <i>no_of_cycles</i>  <b>hysteresis</b> <i>RSSI_in_dBm</i>  <b>probe-auth</b>   <b>probe-only</b> }</p> <p><b>Example:</b></p> <pre>Device(config)#wireless macro-micro steering probe-suppression probe-only</pre>	<p>Configures Micro-Macro probe suppression.</p> <ul style="list-style-type: none"> <li>• <b>aggressiveness</b>—Configures the probe cycles to be suppressed. The <i>no_of_cycles</i> value ranges from 0 to 255.</li> <li>• <b>hysteresis</b>—Configures the hysteresis. The <i>RSSI_in_dBm</i> value ranges from -6 to -3.</li> <li>• <b>probe-auth</b>—Suppresses both probes and single auth.</li> <li>• <b>probe-only</b>—Suppresses only probes.</li> </ul>

	Command or Action	Purpose
Step 3	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Debugging Flexible Radio Assignment (CLI)

- Debug FRA by entering this command:

```
set platform software trace wireless switch active R0 rrm-fra {noise | verbose}
```

```
set platform software trace wireless switch active R0 rrm-fra noise
```

- **noise**—Maximum possible message.
- **verbose**—Verbose debug messages.



## CHAPTER 87

# Configuring Optimized Roaming

- [Information About Optimized Roaming, on page 1481](#)
- [Restrictions for Optimized Roaming, on page 1481](#)
- [Configuring Optimized Roaming \(CLI\), on page 1482](#)

## Information About Optimized Roaming

Optimized roaming resolves the problem of sticky clients that remain associated to access points that are far away and outbound clients that attempt to connect to a Wi-Fi network without having a stable connection. This feature disassociates clients based on the RSSI of the client data packets and data rate. The client is disassociated if the RSSI alarm condition is met and the current data rate of the client is lower than the optimized roaming data rate threshold. You can disable the data rate option so that only RSSI is used for disassociating clients.

Optimized roaming also prevents client association when the client's RSSI is low. This feature checks the RSSI of the incoming client against the RSSI threshold. This check prevents the clients from connecting to a Wi-Fi network unless the client has a viable connection. In many scenarios, even though clients can hear beacons and connect to a Wi-Fi network, the signal might not be strong enough to support a stable connection.

You can also configure the client coverage reporting interval for a radio by using optimized roaming. The client coverage statistics include data packet RSSIs, Coverage Hole Detection and Mitigation (CHDM) prealarm failures, retransmission requests, and current data rates.

Optimized roaming is useful in the following scenarios:

- Addresses the sticky client challenge by proactively disconnecting clients.
- Actively monitors data RSSI packets.
- Disassociates client when the RSSI is lower than the set threshold.

## Restrictions for Optimized Roaming

- You cannot configure the optimized roaming interval until you disable the 802.11a/b network.
- When basic service set (BSS) transition is sent 802.11v-capable clients, and if the clients are not transitioned to other BSS before the disconnect timer expires, the corresponding client is disconnected forcefully. BSS transition is enabled by default for 802.11v-capable clients.

# Configuring Optimized Roaming (CLI)

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>ap dot11 5ghz rrm optimized-roam</b> <b>Example:</b> Device(config)# ap dot11 5ghz rrm optimized-roam	Configures 802.11a or 802.11b optimized roaming.  By default, optimized roaming is disabled.
<b>Step 2</b>	<b>ap dot11 5ghz rrm optimized-roam reporting-interval interval-seconds</b> <b>Example:</b>	Configures the client coverage reporting interval for 802.11a or 802.11b networks.
<b>Step 3</b>	Configure the client coverage reporting interval for 802.11a networks by entering this command:	<b>ap dot11 5ghz rrm optimized-roam reporting-interval interval-seconds</b>  The range is from 5 to 90 seconds. The default value is 90 seconds.  <b>Note</b> You must disable the 802.11a network before you configure the optimized roaming reporting interval.  The access point sends the client statistics to the controller based on the following conditions: <ul style="list-style-type: none"> <li>• When the <b>reporting-interval interval-seconds</b> is set to 90 seconds by default.</li> <li>• When the <b>reporting-interval interval-seconds</b> is configured (for instance to 10 secs) only during optimized roaming failure due to the Coverage Hole Detection (CHD) RED ALARM.</li> </ul>
<b>Step 4</b>	Configure the threshold data rate for 802.11a networks by entering this command:	<b>ap dot11 5ghz rrm optimized-roam data-rate-threshold mbps</b>  For 802.11a, the configurable data rates are 1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48, and 54. You can configure DISABLE to disable the data rate.
<b>Step 5</b>	View information about optimized roaming for each band by entering this command:	<b>show ap dot11 5ghz optimized-roaming</b>



	Command or Action	Purpose
		<pre>(Cisco Controller) &gt; show ap dot11 5ghz <b>optimized-roaming</b> 802.11a OptimizedRoaming  Mode : Disabled Reporting Interval : 90 seconds Rate Threshold : Disabled Hysteresis : 6 db</pre>
<b>Step 6</b>	View information about optimized roaming statistics by entering this command:	<pre><b>show ap dot11 5ghz optimized-roaming statistics</b>  (Cisco Controller) &gt; show ap dot11 5ghz <b>optimized-roaming statistics</b> 802.11a OptimizedRoaming statistics  Disassociations : 0 Rejections : 0</pre>





## CHAPTER 88

# Configuring Rx SOP

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- [Information About Rx-SOP, on page 1485](#)
- [Configuring Rx SOP \(CLI\), on page 1485](#)

## Information About Rx-SOP

Receiver Start of Packet Detection Threshold (Rx SOP) determines the Wi-Fi signal level in dBm at which an access point's radio demodulates and decodes a packet. As the Wi-Fi level increases, the radio sensitivity decreases and the receiver cell size becomes smaller. Reduction of the cell size affects the distribution of clients in the network.

Rx SOP is used to address clients with weak RF links, sticky clients, and client load balancing across access points. Rx SOP helps to optimize the network performance at high-density deployments such as stadiums and auditoriums where access points need to optimize the nearest and strongest clients.

## Configuring Rx SOP (CLI)

### Procedure

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- Step 1** Configure the Rx SOP mode by entering this command:
- ```
ap dot11 {24ghz | 5ghz} rx-sop threshold {auto | high | low | medium}
```
- Step 2** Verify Rx SOP high-density parameters:
- ```
show ap dot11 24ghz high-density
```

```
Controller# show ap dot11 24ghz high-density
Receiver Start-of-Packet threshold: auto
Multicast Data Rate: auto
AP Name : AP5475.d064.0552
Receiver Start-of-Packet threshold: auto
Multicast Data Rate: auto 2:33 PM
```

---





## CHAPTER 89

# Configuring AirTime Fairness

- [Information About Air Time Fairness, on page 1487](#)
- [Configure, View, and Modify AirTime Fairness, on page 1489](#)

## Information About Air Time Fairness

Cisco Air Time Fairness (ATF) for Cisco High Density Experience (HDX) functions as a wireless quality of service (QoS) that regulates the downlink air time. It allows network administrators to create and apply policies to enable some groups to receive traffic from a WLAN more frequently than other groups.

Cisco ATF has the following capabilities:

- Allocates Wi-Fi air time for user groups or device categories.
- Cisco ATF is defined by the network administrator, and not by the network.
- Provides a simplified mechanism for allocating air time.
- Dynamically adapts to changing conditions in a WLAN.
- Enables a more efficient fulfillment of service-level agreements.
- Augments standards-based Wi-Fi QoS mechanisms.

By enabling network administrators to define what fairness means within their environments with regard to the amount of on air time per client group, the amount of traffic is also controlled.

Policies are created to allow, prevent, and prioritize data packets in a network. All the policies that are created must have a weight value that denotes the importance of that policy in the network. You can assign a weight value in the range of 5 to 100. If no policy is assigned to a WLAN, the system will assign the default policy (policy ID 0) with a weight value of 10 to it. The weight value impacts the percentage of air-time assigned to a policy. The air time percentage is calculated by the system without any user intervention. Therefore, air time percentages will automatically change when a WLAN and a policy are added or removed from a network.



**Note** When percentages change, the changed values might not be optimal for the new traffic.

For example, if there are three WLANs with policy values of 5, 10, and 35 in a network, the calculations for the air time percentage for weight value 5 is 10%, and for weight values of 10 and 35, it is 20% and 70% air

time respectively. If you add a new policy of weight 15, the system recalculates the air time percentages as 7.7%, 15.38%, 23.07%, and 53.84%, or 5, 10, 15, 35 weight values respectively.

Cisco ATF has three modes, that can be subdivided into three levels per mode, thus providing flexibility in the configuration. The three modes are:

- **Disable mode**—ATF is disabled in a Cisco WLC. The default option is **Disable**.
- **Monitor mode**—Users can perform the following actions:
  - View the air time
  - Report air time usage for all AP transmissions
  - View reports
    - Per SSID/WLAN
    - Per AP Group
    - Per AP
  - Report air time usage at periodic intervals
  - Block ACKs are not reported
  - Enforcement disabled as part of Monitor mode
- **Enforce-policy mode**—Users can perform the following functions:
  - Enforce air time based on configured policy
  - Enforce air time on
    - A WLAN
    - All APs connected within a Cisco WLC's network
    - An AP group
    - An AP
  - **Strict Enforcement per WLAN**—Air time used by the WLANs on a radio will be strictly enforced up to the configured limits in the policies.
  - **Optimal Enforcement per WLAN**—Share unused Air time from other SSIDs that are not using their allocated air time.



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**Note** AP group Global configuration and per AP level Privileged EXEC commands are allowed to override a policy applied on a WLAN and air time fairness mode applied at the radio level.

---

# Configure, View, and Modify AirTime Fairness

## Configuring Cisco Air Time Fairness (CLI)

The Cisco Air Time Fairness (ATF) feature can be configured using the following CLIs:

- Enable Cisco ATF in the Enforce policy mode or Monitor mode by entering this command:

```
ap dot11 {24ghz | 5ghz} airtime-fairness mode {enforce-policy | monitor}
```

- Disable Cisco ATF in the Enforce policy mode or Monitor mode by entering this command:

```
no ap dot11 {24ghz | 5ghz} airtime-fairness mode {enforce-policy | monitor}
```

- Create a new ATF policy and apply policy weight by entering this command:

1. **controller#configure terminal**
2. **controller(config)# ap dot11 airtime-fairness policy-name *policy-name policy-id***
3. **controller(config-airtime-fairness policy)# policy-weight *policy-weight***

The range for a policy weight is between 05 and 100. The default value of 10 is applied if no policy is applied to the corresponding WLAN.

- Delete a policy by entering this command:

```
no ap dot11 airtime-fairness policy-name policy-name
```

- Configure a Cisco ATF policy for a WLAN by using these commands:

1. **controller#configure terminal**
2. **controller(config)# wlan *wlan-name***
3. **controller(config-wlan)# airtime-fairness policy *policy-name***

- Configure Cisco ATF mode for an AP group by using these commands:

1. **controller#configure terminal**
2. **controller(config)# ap group *apgroup-name***
3. **controller(config-apgroup)# no airtime-fairness dot11 {24ghz | 5ghz} mode {enforce-policy | monitor}**

- Configure Cisco ATF optimization for an AP group by using these commands:

1. **controller#configure terminal**
2. **controller(config)# ap group *apgroup-name***
3. **controller(config-apgroup)# no airtime-fairness dot11 {24ghz | 5ghz} optimization**

- Configure applied policy override on a WLAN through an AP-specific WLAN list by using these commands:

1. **controller#configure terminal**
2. **controller(config)# ap group *apgroup-name***
3. **controller(config-apgroup)# wlan *wlan-name***
4. **controller(config-wlan-apgroup)# no airtime-fairness dot11 {24ghz | 5ghz} policy *policy-name***

- Configure a Cisco ATF policy for a WLAN by using these commands:

1. **controller# configure terminal**
  2. **controller(config)# wlan *wlan-name***
  3. **controller(config-wlan)# airtime-fairness policy *policy-name***
- Clear wireless ATF statistics by entering this command:
    1. **controller# clear wireless airtime-fairness statistics**

## Viewing Cisco Air Time Fairness (CLI)

Cisco Air Time Fairness (ATF) feature configurations can be viewed using the following CLIs:

- View all the configured policies by entering this command:
 

```
show ap airtime-fairness policy
```
- View the list of configured WLANs, and the ATF policy applied by entering this command:
 

```
show ap airtime-fairness wlan
```
- View the ATF configuration for a specific AP group by entering this command:
 

```
show ap airtime-fairness ap-group group-name
```
- View the AP list with ATF configuration per radio by entering this command:
 

```
show ap airtime-fairness
```
- View the AP list with ATF configured for 2.4-GHz and 5-GHz radio by entering this command:
 

```
show ap dot11 {24ghz | 5ghz} airtime-fairness
```
- View ATF configuration for a specific AP
 

```
show ap name ap-name airtime-fairness
```
- View statistics for specified ATF policy
 

```
show ap name ap-name dot11 {24ghz | 5ghz} airtime-fairness policy policy-name statistics
```
- View ATF statistics for a specified WLAN active on specific AP
 

```
show ap name ap-name dot11 {24ghz | 5ghz} airtime-fairness wlan name wlan-name statistics
```
- View ATF statistics per WLAN
 

```
show ap name ap-name dot11 {24ghz | 5ghz} airtime-fairness summary
```

## Modifying AirTime Fairness Parameters for AP(CLI)

The following commands allows modification of specific AP ATF parameters. The user can enable, disable, change, or override ATF policy per AP using these commands

- Enable ATF in enforce-policy or monitor mode for a specific AP
 

```
ap name ap-name dot11 {24ghz | 5ghz} airtime-fairness mode {enforce-policy | monitor}
```
- Disable ATF in enforce-policy or monitor mode for a specific AP
 

```
ap name ap-name no dot11 {24ghz | 5ghz} airtime-fairness mode {enforce-policy | monitor}
```



- Enable ATF optimization for a specific AP

**ap name** *ap-name* **dot11** {24ghz | 5ghz} **airtime-fairness optimization**

- Disable ATF optimization for a specific AP

**ap name** *ap-name* **no dot11** {24ghz | 5ghz} **airtime-fairness optimization**

- Override the policy on WLAN specific to one AP

**ap name** *ap-name* **dot11** {24ghz | 5ghz} **airtime-fairness wlan-name** *wlan-name* **policy-name**  
*policy-name*

- Disable the ATF policy override on the WLAN specific to WLAN

**ap name** *ap-name* **no dot11** {24ghz | 5ghz} **airtime-fairness wlan-name** *wlan-name*





## CHAPTER 90

# Configuring RF Profiles on CA

- [Prerequisites for RF Profile on CA, on page 1493](#)
- [Restrictions for RF Profile on CA, on page 1493](#)
- [Information About RF Profile on CA, on page 1494](#)
- [RF Profile Customizations, on page 1495](#)
- [How to Configure RF Profile on CA, on page 1497](#)

## Prerequisites for RF Profile on CA

The latest RF Profile settings are applied to an AP group (new or modified). The rule of the same RF Profile to be applied on every controller of the AP group comes into effect or the activation fails for that controller.



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**Note** The same RF Profile can be assigned to multiple AP groups.

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## Restrictions for RF Profile on CA

- When Centralized Mode is enabled, configuration is lost at reboot and must be reconfigured.



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**Note** Cisco Communications Media Module (CMM) feature is deprecated.

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- Configurations must be exactly the same at the MC and at all the MAs.
- Custom power settings on an AP is not supported.
- RF Profile is active only when channel and the transmit power (TPC) is managed by RRM on all APs.
- An RF Profile which is applied to an AP group cannot be deleted.
- You need to shutdown the RF profile which is assigned to an AP group to make any changes to its settings.
- Changing the RF Profile assignment within the AP group on either of the bands causes the AP to reboot.

## Information About RF Profile on CA

RF Profile on Converged Access (CA) (local mode only) allows customization to groups of APs that share a common radio configuration. Special RF profiles can be created per 802.11 band. These RF profiles have default settings for all the existing RF parameters and additional new configurations.

Newly installed APs are by default assigned to the 'default group' AP group. The radios are disabled to eliminate any RF interference. The new APs need to be manually added to an AP group if RF Profile configurations need to be applied to them.

RF profiles are applied to all APs that belong to an AP group, where all APs in that group have the same profile settings. The priority order of configurations for APs in an AP Group that has an RF Profile attached is as follows:

1. AP specific.
2. RF-Profile.
3. Global.

The priorities of Rx-SOP and Multicast data rate do not follow the priority order. They follow the following rules:

- If an AP is in an AP group with an RF profile attached, between RF profile configuration and AP specific configuration, the configuration done last takes precedence.
- If the AP is not in an AP group, or the AP group does not have an RF profile, then between global configuration and AP specific configuration, the configuration done last takes precedence.
- When an RF Profile is removed, the last RF Profile configuration is stored in the AP. This stored configuration gets applied when the AP is added back.

The RF Profile on CA feature allows customization of the following configurations:

- Band Select Configurations.
- Coverage Hole Mitigation Configurations.
- Dynamic Channel Assignment (DCA) Configurations.
- High Density Configurations.
- Load Balancing Configurations.
- Stadium Vision Configurations.
- Transmit Power Control (TPC) Configurations.

# RF Profile Customizations

## Band Select Configurations

This configuration addresses client distribution between the 2.4-GHz and 5-GHz bands by identifying client capabilities. Enabling band select on a WLAN forces the AP to suppress 2.4-GHz band to move dual band clients to 5-GHz spectrum. The following band select parameters can be configured per AP Group:

- Probe response—probe responses to clients. You can enable or disable this function.
- Probe Cycle Count—probe cycle count for the RF profile. The cycle count sets the number of suppression cycles for a new client.
- Cycle Threshold—time threshold for a new scanning RF Profile band select cycle period. This setting determines the time threshold during which new probe requests from a client come in a new scanning cycle.
- Suppression Expire—expiration time for pruning previously known 802.11b/g clients. After this time elapses, clients become new and are subject to probe response suppression.
- Dual Band Expire—expiration time for pruning previously known dual-band clients. After this time elapses, clients become new and are subject to probe response suppression.
- Client RSSI—minimum RSSI for a client to respond to a probe.

## Coverage Hole Mitigation Configurations

For Coverage Hole Mitigation, the following parameters can be configured under this feature:

- Data RSSI—minimum receive signal strength indication (RSSI) value for data packets received by the access point. The value that you enter is used to identify coverage holes (or areas of poor coverage) within your network.
- Voice RSSI—minimum receive signal strength indication (RSSI) value for voice packets received by the access point.
- Coverage Exception—percentage of clients on an access point that are experiencing a low signal level but cannot roam to another access point. If an access point has more number of such clients than the configured coverage level it triggers a coverage hole event.
- Coverage Level—minimum number of clients on an access point with an RSSI value at or below the data or voice RSSI threshold to trigger a coverage hole exception.

## Dynamic Channel Assignment Configurations

For Dynamic Channel Assignment (DCA), the following parameters can be configured under this feature:

- Avoid foreign AP interference—DCA algorithm bases its optimization on multiple sets of inputs, which include detected traffic and interference from foreign 802.11 traffic access points. Each access point periodically measures interference, noise level, foreign interference, and load and maintains a list of

neighbor APs. Foreign AP interference is that which is received from 802.11 non-neighbors. This interference is measured using the same mechanism as the noise level.

- Channel width—You can choose one of the following channel width options to specify the channel bandwidth supported for all 802.11n and 802.11ac radios in the 5-GHz band.
  - 20 MHz—20 MHz is also the maximum channel width allowed for 2.4 GHz. This is the default value for channel width.
  - 40 MHz—The 40-MHz channel bandwidth.
  - 80 MHz—The 80-MHz channel bandwidth.
- DCA channel list—You can choose a channel set used by DCA to assign one of the channels to an access point radio. The channel set selected for an RF profile must be a subset of the DCA global channel list. The available channels are preselected based on the globally configured countries. DCA compares the metrics measured on these channels and selects the most suitable channel.
- Trap thresholds—The profile threshold for the traps can be configured for the specific AP groups based on the RF profiles.

## High Density Configurations

The following configurations are available to fine tune RF environments in a dense wireless network:

- Client limit per WLAN or radio: maximum number of clients that can communicate with the AP in a high-density environment.
- Client trap threshold: threshold value of the number of clients that associate with an access point, after which an SNMP trap is sent to the controller and Cisco Prime Infrastructure.

## Load Balancing Configurations

Load balancing maintains fair distribution of clients across APs. You can configure the following parameters:

- Window—load balancing sets client association limits by enforcing a client window size.
- Denial—the denial count sets the maximum number of association denials during load balancing.

## Stadium Vision Configurations

For Stadium Vision, the following parameters can be configured under this feature:

- Multicast data rates—configurable data rate for multicast traffic based on the RF condition of an AP.

## Transmit Power Control Configurations

For Transmit Power Control (TPC), the following parameters can be configured under this feature:

- Minimum Power—minimum allowed power for the APs belonging to the AP group where the RF Profile is applied.

- Maximum Power—maximum allowed power for the APs belonging to the AP group where the RF Profile is applied.
- Threshold—if the power of the strongest neighbors is above the configured threshold, then the RRM runs for the APs in the AP group where the RF Profile is applied.

## How to Configure RF Profile on CA

### Configuring RF-Profile parameters

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>ap dot11 24ghz rf-profile <i>profile-name</i></b> <b>Example:</b> Device (config) # <b>ap dot11 24ghz rf-profile doctest</b>	Configuring the RF profile for a selected Band.
<b>Step 2</b>	<b>band-select client rssi <i>value</i></b> <b>Example:</b> Device (config-rf-profile) # <b>band-select client rssi -50</b>	Sets the Band Select client thresholds with minimum dBm for a client to start or respond to a probe. <b>Note</b> This option is available only on 2.4GHz band.
<b>Step 3</b>	<b>channel add <i>channel#</i></b> <b>Example:</b> Device (config-rf-profile) # <b>channel add 2</b>	This command adds non-default channels to the RF Profile DCA channel list.
<b>Step 4</b>	<b>channel delete <i>channel#</i></b> <b>Example:</b> Device (config-rf-profile) # <b>channel delete 2</b>	The delete command removes the default channel from the RF Profile DCA channel list.
<b>Step 5</b>	<b>channel width <i>value</i></b> <b>Example:</b> Device (config-rf-profile) # <b>channel width 40</b>	Configures the RF Profile DCA channel width. <b>Note</b> This option is available only on 5GHz band.

	Command or Action	Purpose
<b>Step 6</b>	<b>coverage voice rssi threshold</b> <i>value</i> <b>Example:</b> Device(config-rf-profile)# <b>coverage voice rssi threshold -50</b>	Configures the RF Profile Coverage and the RSSI threshold for Coverage Hole Detection for voice packets.
<b>Step 7</b>	<b>coverage exception</b> <i>value</i> <b>Example:</b> Device(config-rf-profile)# <b>coverage exception 60</b>	Sets Cisco AP coverage exception level.
<b>Step 8</b>	<b>dot11n-only</b> <b>Example:</b> Device(config-rf-profile)# <b>channel dot11n-only</b>	Enable 802.11n client only mode of the RF Profile.
<b>Step 9</b>	<b>load-balancing denial</b> <i>value</i> <b>Example:</b> Device(config-rf-profile)# <b>load-balancing denial 8</b>	Configures the RF Profile Load Balance and load balancing denial count.
<b>Step 10</b>	<b>high-density clients count</b> <i>value</i> <b>Example:</b> Device(config-rf-profile)# <b>high-density clients count 160</b>	Configures the RF Profile High Density client count value.
<b>Step 11</b>	<b>rate</b> <i>rate</i> <b>disable</b> <b>Example:</b> Device(config-rf-profile)# <b>rate RATE_1M disable</b>	Disables the 802.11 operational rates for a selected rate profile.
<b>Step 12</b>	<b>trap threshold clients</b> <i>value</i> <b>Example:</b> Device(config-rf-profile)# <b>trap threshold clients 145</b>	Configures the RF Profile Trap threshold for number of client associated to an AP after the trap is set.
<b>Step 13</b>	<b>tx-power min</b> <i>value</i> <b>Example:</b> Device(config-rf-profile)# <b>tx-power min -10</b>	Sets the minimum transmission power levels.



	Command or Action	Purpose
<b>Step 14</b>	<b>Shutdown</b> <b>Example:</b> Device(config-rf-profile) # <b>Shutdown</b>	Shuts down the profile and disables network.
<b>Step 15</b>	<b>ap group <i>group-name</i></b> <b>Example:</b> Device(config) # <b>ap group docgroup</b>	Configures RF Profile to a AP group
<b>Step 16</b>	<b>remote-lan <i>rlan-name</i></b> <b>Example:</b> Device(config-apgroup) # <b>remote-lan labtest</b>	Configuring Remote-LAN to a AP group.
<b>Step 17</b>	<b>wlan <i>wlan-name</i></b> <b>Example:</b> Device(config-apgroup) # <b>wlan labwantest</b>	Configuring WLAN to a AP group.
<b>Step 18</b>	<b>rf-profile dot11 24ghz <i>profile-name</i></b> <b>Example:</b> Device(config-apgroup) # <b>rf-profile dot11 24ghz doctest</b>	Configuring 802.11b RF Profile to a AP group.
<b>Step 19</b>	<b>rf-profile dot11 5ghz <i>profile-name</i></b> <b>Example:</b> Device(config-apgroup) # <b>rf-profile dot11 5ghz doc5test</b>	Configuring 802.11a RF Profile to a AP group.
<b>Step 20</b>	<b>show ap rf-profile name <i>profile-name</i> detail</b> <b>Example:</b> Device# <b>show ap rf-profile name doctest detail</b>	Displays the RF Profile configuration details.
<b>Step 21</b>	<b>show ap rf-profile summary</b> <b>Example:</b> Device# <b>show ap rf-profile summary</b>	Displays the summary of the RF Profiles.
<b>Step 22</b>	<b>show ap groups</b> <b>Example:</b> Device# <b>show ap groups</b>	Displays the ap groups summary.





## PART **XVI**

### **Routing**

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- [Configuring MSDP, on page 1525](#)
- [Configuring IP Unicast Routing, on page 1549](#)





## CHAPTER 91

# Configuring Bidirectional Forwarding Detection

- [Bidirectional Forwarding Detection, on page 1503](#)

## Bidirectional Forwarding Detection

This document describes how to enable the Bidirectional Forwarding Detection (BFD) protocol. BFD is a detection protocol that is designed to provide fast forwarding path failure detection times for all media types, encapsulations, topologies, and routing protocols.

BFD provides a consistent failure detection method for network administrators, in addition to fast forwarding path failure detection. Because the network administrator can use BFD to detect forwarding path failures at a uniform rate, rather than the variable rates for different routing protocol hello mechanisms, network profiling and planning will be easier, and reconvergence time will be consistent and predictable.

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Bidirectional Forwarding Detection

- Cisco Express Forwarding and IP routing must be enabled on all participating switches.
- One of the IP routing protocols supported by BFD must be configured on the switches before BFD is deployed. You should implement fast convergence for the routing protocol that you are using. See the IP routing documentation for your version of Cisco IOS software for information on configuring fast convergence. See the Restrictions for Bidirectional Forwarding Detection section for more information on BFD routing protocol support in Cisco IOS software.

## Restrictions for Bidirectional Forwarding Detection

- BFD works only for directly connected neighbors. BFD neighbors must be no more than one IP hop away. Multihop configurations are not supported.
- BFD support is not available for all platforms and interfaces. To confirm BFD support for a specific platform or interface and obtain the most accurate platform and hardware restrictions, see the Cisco IOS software release notes for your software version.
- BFD packets are not matched in the QoS policy for self-generated packets.
- BFD packets are matched in the **class class-default** command. So, the user must make sure of the availability of appropriate bandwidth to prevent dropping of BFD packets due to oversubscription.
- BFD HA support is not available starting Cisco Denali IOS XE 16.3.1

## Information About Bidirectional Forwarding Detection

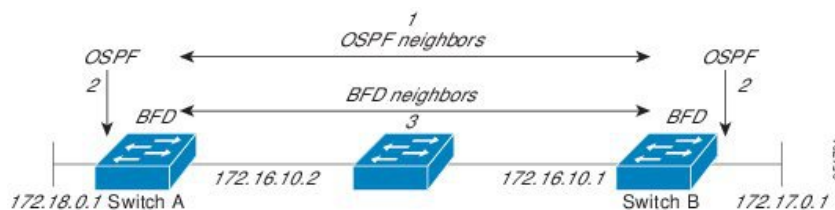
### BFD Operation

BFD provides a low-overhead, short-duration method of detecting failures in the forwarding path between two adjacent routers, including the interfaces, data links, and forwarding planes.

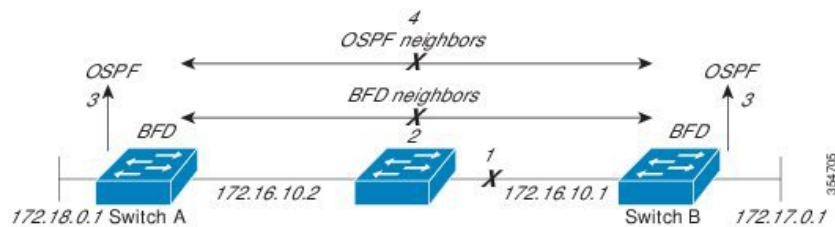
BFD is a detection protocol that you enable at the interface and routing protocol levels. Cisco supports BFD asynchronous mode, which depends on the sending of BFD control packets between two systems to activate and maintain BFD neighbor sessions between routers. Therefore, in order for a BFD session to be created, you must configure BFD on both systems (or BFD peers). Once BFD has been enabled on the interfaces and at the router level for the appropriate routing protocols, a BFD session is created, BFD timers are negotiated, and the BFD peers will begin to send BFD control packets to each other at the negotiated interval.

### Neighbor Relationships

BFD provides fast BFD peer failure detection times independently of all media types, encapsulations, topologies, and routing protocols BGP, EIGRP, IS-IS, and OSPF. By sending rapid failure detection notices to the routing protocols in the local router to initiate the routing table recalculation process, BFD contributes to greatly reduced overall network convergence time. The figure below shows a simple network with two routers running OSPF and BFD. When OSPF discovers a neighbor (1) it sends a request to the local BFD process to initiate a BFD neighbor session with the OSPF neighbor router (2). The BFD neighbor session with the OSPF neighbor router is established (3).



The figure below shows what happens when a failure occurs in the network (1). The BFD neighbor session with the OSPF neighbor router is torn down (2). BFD notifies the local OSPF process that the BFD neighbor is no longer reachable (3). The local OSPF process tears down the OSPF neighbor relationship (4). If an alternative path is available, the routers will immediately start converging on it.



A routing protocol needs to register with BFD for every neighbor it acquires. Once a neighbor is registered, BFD initiates a session with the neighbor if a session does not already exist.

OSPF registers with BFD when:

- A neighbor finite state machine (FSM) transitions to full state.
- Both OSPF BFD and BFD are enabled.

On broadcast interfaces, OSPF establishes a BFD session only with the designated router (DR) and backup designated router (BDR), but not between any two routers in DROTHER state.

### BFD Detection of Failures

Once a BFD session has been established and timer negotiations are complete, BFD peers send BFD control packets that act in the same manner as an IGP hello protocol to detect liveness, except at a more accelerated rate. The following information should be noted:

- BFD is a forwarding path failure detection protocol. BFD detects a failure, but the routing protocol must take action to bypass a failed peer.
- Starting Cisco IOS XE Denali 16.3.1, Cisco devices will support BFD version 0, where devices will use one BFD session for multiple client protocols in the implementation. For example, if a network is running OSPF and EIGRP across the same link to the same peer, only one BFD session will be established, and BFD will share session information with both routing protocols.

### BFD Version Interoperability

All BFD sessions come up as Version 1 by default and will be interoperable with Version 0. The system automatically performs BFD version detection, and BFD sessions between neighbors will run in the highest common BFD version between neighbors. For example, if one BFD neighbor is running BFD Version 0 and the other BFD neighbor is running Version 1, the session will run BFD Version 0. The output from the **show bfd neighbors [details]** command will verify which BFD version a BFD neighbor is running.

See the Example Configuring BFD in an EIGRP Network with Echo Mode Enabled by Default for an example of BFD version detection.

### BFD Session Limits

Starting Cisco IOS XE Denali 16.3.1, the number of BFD sessions that can be created has been increased to 100.

### BFD Support for Nonbroadcast Media Interfaces

Starting Cisco IOS XE Denali 16.3.1, the BFD feature is supported on routed, SVI and L3 portchannels.

The **bfd interval** command must be configured on the interface to initiate BFD monitoring.

## BFD Support for Nonstop Forwarding with Stateful Switchover

Typically, when a networking device restarts, all routing peers of that device detect that the device went down and then came back up. This transition results in a routing flap, which could spread across multiple routing domains. Routing flaps caused by routing restarts create routing instabilities, which are detrimental to the overall network performance. Nonstop forwarding (NSF) helps to suppress routing flaps in devices that are enabled with stateful switchover (SSO), thereby reducing network instability.

NSF allows for the forwarding of data packets to continue along known routes while the routing protocol information is being restored after a switchover. With NSF, peer networking devices do not experience routing flaps. Data traffic is forwarded through intelligent line cards or dual forwarding processors while the standby RP assumes control from the failed active RP during a switchover. The ability of line cards and forwarding processors to remain up through a switchover and to be kept current with the Forwarding Information Base (FIB) on the active RP is key to NSF operation.

In devices that support dual RPs, SSO establishes one of the RPs as the active processor; the other RP is designated as the standby processor, and then synchronizes information between them. A switchover from the active to the standby processor occurs when the active RP fails, when it is removed from the networking device, or when it is manually taken down for maintenance.

## BFD Support for Stateful Switchover

The BFD protocol provides short-duration detection of failures in the path between adjacent forwarding engines. In network deployments that use dual RP routers or switches (to provide redundancy), the routers have a graceful restart mechanism that protects the forwarding state during a switchover between the active RP and the standby RP.

The dual RPs have variable switchover times that depend on the ability of the hardware to detect a communication failure. When BFD is running on the RP, some platforms are not able to detect a switchover before the BFD protocol times out; these platforms are referred to as slow switchover platforms.

## BFD Support for Static Routing

Unlike dynamic routing protocols, such as OSPF and BGP, static routing has no method of peer discovery. Therefore, when BFD is configured, the reachability of the gateway is completely dependent on the state of the BFD session to the specified neighbor. Unless the BFD session is up, the gateway for the static route is considered unreachable, and therefore the affected routes will not be installed in the appropriate Routing Information Base (RIB).

For a BFD session to be successfully established, BFD must be configured on the interface on the peer and there must be a BFD client registered on the peer for the address of the BFD neighbor. When an interface is used by dynamic routing protocols, the latter requirement is usually met by configuring the routing protocol instances on each neighbor for BFD. When an interface is used exclusively for static routing, this requirement must be met by configuring static routes on the peers.

If a BFD configuration is removed from the remote peer while the BFD session is in the up state, the updated state of the BFD session is not signaled to IPv4 static. This will cause the static route to remain in the RIB. The only workaround is to remove the IPv4 static BFD neighbor configuration so that the static route no longer tracks BFD session state. Also, if you change the encapsulation type on a serial interface to one that is unsupported by BFD, BFD will be in a down state on that interface. The workaround is to shut down the interface, change to a supported encapsulation type, and then reconfigure BFD.

A single BFD session can be used by an IPv4 static client to track the reachability of next hops through a specific interface. You can assign a BFD group for a set of BFD-tracked static routes. Each group must have one active static BFD configuration, one or more passive BFD configurations, and the corresponding static routes to be BFD-tracked. Nongroup entries are BFD-tracked static routes for which a BFD group is not



assigned. A BFD group must accommodate static BFD configurations that can be part of different VRFs. Effectively, the passive static BFD configurations need not be in the same VRF as that of the active configuration.

For each BFD group, there can be only one active static BFD session. You can configure the active BFD session by adding a static BFD configuration and a corresponding static route that uses the BFD configuration. The BFD session in a group is created only when there is an active static BFD configuration and the static route that uses the static BFD configuration. When the active static BFD configuration or the active static route is removed from a BFD group, all the passive static routes are withdrawn from the RIB. Effectively, all the passive static routes are inactive until an active static BFD configuration and a static route to be tracked by the active BFD session are configured in the group.

Similarly, for each BFD group, there can be one or more passive static BFD configurations and their corresponding static routes to be BFD-tracked. Passive static session routes take effect only when the active BFD session state is reachable. Though the active BFD session state of the group is reachable, the passive static route is added to the RIB only if the corresponding interface state is up. When a passive BFD session is removed from a group, it will not affect the active BFD session if one existed, or the BFD group reachability status.

## Benefits of Using BFD for Failure Detection

When you deploy any feature, it is important to consider all the alternatives and be aware of any trade-offs being made.

The closest alternative to BFD in conventional EIGRP, IS-IS, and OSPF deployments is the use of modified failure detection mechanisms for EIGRP, IS-IS, and OSPF routing protocols.

If you set EIGRP hello and hold timers to their absolute minimums, the failure detection rate for EIGRP falls to within a one- to two-second range.

If you use fast hellos for either IS-IS or OSPF, these Interior Gateway Protocol (IGP) protocols reduce their failure detection mechanisms to a minimum of one second.

There are several advantages to implementing BFD over reduced timer mechanisms for routing protocols:

- Although reducing the EIGRP, IS-IS, and OSPF timers can result in minimum detection timer of one to two seconds, BFD can provide failure detection in less than one second.
- Because BFD is not tied to any particular routing protocol, it can be used as a generic and consistent failure detection mechanism for EIGRP, IS-IS, and OSPF.
- Because some parts of BFD can be distributed to the data plane, it can be less CPU-intensive than the reduced EIGRP, IS-IS, and OSPF timers, which exist wholly at the control plane.

## How to Configure Bidirectional Forwarding Detection

### Configuring BFD Session Parameters on the Interface

To configure BFD on an interface, you need to set the baseline BFD session parameters on an interface. Repeat the steps in this procedure for each interface over which you want to run BFD sessions to BFD neighbors.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	Perform one of the following steps: <ul style="list-style-type: none"> <li>• <b>ip address</b> <i>ipv4-address mask</i></li> <li>• <b>ipv6 address</b> <i>ipv6-address/mask</i></li> </ul> <b>Example:</b> Configuring an IPv4 address for the interface: <pre>Device(config-if)# ip address 10.201.201.1 255.255.255.0</pre> Configuring an IPv6 address for the interface: <pre>Device(config-if)# ipv6 address 2001:db8:1:1::1/32</pre>	Configures an IP address for the interface.
<b>Step 4</b>	<b>bfd interval</b> <i>milliseconds min_rx milliseconds multiplier interval-multiplier</i> <b>Example:</b> <pre>Device(config-if)# bfd interval 100 min_rx 100 multiplier 3</pre>	Enables BFD on the interface. The BFD interval configuration is removed when the subinterface on which it is configured is removed. The BFD interval configuration is not removed when: <ul style="list-style-type: none"> <li>• an IPv4 address is removed from an interface</li> <li>• an IPv6 address is removed from an interface</li> <li>• IPv6 is disabled from an interface</li> <li>• an interface is shutdown</li> <li>• IPv4 CEF is disabled globally or locally on an interface</li> <li>• IPv6 CEF is disabled globally or locally on an interface</li> </ul>

	Command or Action	Purpose
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config-if)# end</pre>	Exits interface configuration mode and returns to privileged EXEC mode.

## Configuring BFD Support for Dynamic Routing Protocols

### Configuring BFD Support for eBGP

This section describes the procedure for configuring BFD support for BGP so that BGP is a registered protocol with BFD and will receive forwarding path detection failure messages from BFD.

#### Before you begin

e BGP must be running on all participating routers.

The baseline parameters for BFD sessions on the interfaces over which you want to run BFD sessions to BFD neighbors must be configured. See the Configuring BFD Session Parameters on the Interface section for more information.



**Note** Output from the **show bfd neighbors details** command shows the configured intervals.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>router bgp <i>as-tag</i></b> <b>Example:</b> <pre>Device(config)# router bgp tag1</pre>	Specifies a BGP process and enters router configuration mode.
<b>Step 4</b>	<b>neighbor <i>ip-address</i> fall-over bfd</b> <b>Example:</b> <pre>Device(config-router)# neighbor 172.16.10.2 fall-over bfd</pre>	Enables BFD support for fallover.

	Command or Action	Purpose
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config-router)# end</pre>	Exits router configuration mode and returns the router to privileged EXEC mode.
<b>Step 6</b>	<b>show bfd neighbors [details]</b> <b>Example:</b> <pre>Device# show bfd neighbors detail</pre>	(Optional) Verifies that the BFD neighbor is active and displays the routing protocols that BFD has registered.
<b>Step 7</b>	<b>show ip bgp neighbor</b> <b>Example:</b> <pre>Device# show ip bgp neighbor</pre>	(Optional) Displays information about BGP and TCP connections to neighbors.

### Configuring BFD Support for EIGRP

This section describes the procedure for configuring BFD support for EIGRP so that EIGRP is a registered protocol with BFD and will receive forwarding path detection failure messages from BFD. There are two methods for enabling BFD support for EIGRP:

- You can enable BFD for all of the interfaces for which EIGRP is routing by using the **bfd all-interfaces** command in router configuration mode.
- You can enable BFD for a subset of the interfaces for which EIGRP is routing by using the **bfd interface type number** command in router configuration mode.

#### Before you begin

EIGRP must be running on all participating routers.

The baseline parameters for BFD sessions on the interfaces over which you want to run BFD sessions to BFD neighbors must be configured. See the Configuring BFD Session Parameters on the Interface section for more information.



**Note** Output from the **show bfd neighbors details** command shows the configured intervals.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>router eigrp as-number</b> <b>Example:</b>  Device(config)# router eigrp 123	Configures the EIGRP routing process and enters router configuration mode.
<b>Step 4</b>	Do one of the following: <ul style="list-style-type: none"> <li>• <b>bfd all-interfaces</b></li> <li>• <b>bfd interface type number</b></li> </ul> <b>Example:</b>  Device(config-router)# bfd all-interfaces  <b>Example:</b>  Device(config-router)# bfd interface GigabitFastEthernet 1/0/1	Enables BFD globally on all interfaces associated with the EIGRP routing process.  or  Enables BFD on a per-interface basis for one or more interfaces associated with the EIGRP routing process.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config-router) end	Exits router configuration mode and returns the router to privileged EXEC mode.
<b>Step 6</b>	<b>show bfd neighbors [details]</b> <b>Example:</b>  Device# show bfd neighbors details	(Optional) Verifies that the BFD neighbor is active and displays the routing protocols that BFD has registered.
<b>Step 7</b>	<b>show ip eigrp interfaces [type number] [as-number] [detail]</b> <b>Example:</b>  Device# show ip eigrp interfaces detail	(Optional) Displays the interfaces for which BFD support for EIGRP has been enabled.

### Configuring BFD Support for IS-IS

This section describes the procedures for configuring BFD support for IS-IS so that IS-IS is a registered protocol with BFD and will receive forwarding path detection failure messages from BFD. There are two methods for enabling BFD support for IS-IS:

- You can enable BFD for all of the interfaces on which IS-IS is supporting IPv4 routing by using the **bfd all-interfaces** command in router configuration mode. You can then disable BFD for one or more of those interfaces using the **isis bfd disable** command in interface configuration mode.

- You can enable BFD for a subset of the interfaces for which IS-IS is routing by using the **isis bfd** command in interface configuration mode.

To configure BFD support for IS-IS, perform the steps in one of the following sections:

### Prerequisites

IS-IS must be running on all participating routers.

The baseline parameters for BFD sessions on the interfaces that you want to run BFD sessions to BFD neighbors over must be configured. See the Configuring BFD Session Parameters on the Interface section for more information.



**Note** Output from the **show bfd neighbors details** command shows the configured intervals. The output does not show intervals that were changed because hardware-offloaded BFD sessions were configured with Tx and Rx intervals that are not multiples of 50 ms.

### Configuring BFD Support for IS-IS for All Interfaces

To configure BFD on all IS-IS interfaces that support IPv4 routing, perform the steps in this section.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>router isis area-tag</b> <b>Example:</b> Device(config)# router isis tag1	Specifies an IS-IS process and enters router configuration mode.
<b>Step 4</b>	<b>bfd all-interfaces</b> <b>Example:</b> Device(config-router)# bfd all-interfaces	Enables BFD globally on all interfaces associated with the IS-IS routing process.
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config-router)# exit	(Optional) Returns the router to global configuration mode.

	Command or Action	Purpose
<b>Step 6</b>	<b>interface</b> <i>type number</i> <b>Example:</b>  Device(config)# interface fastethernet 6/0	(Optional) Enters interface configuration mode.
<b>Step 7</b>	<b>ip router isis</b> [ <i>tag</i> ] <b>Example:</b>  Device(config-if)# ip router isis tag1	(Optional) Enables support for IPv4 routing on the interface.
<b>Step 8</b>	<b>isis bfd</b> [ <b>disable</b> ] <b>Example:</b>  Device(config-if)# isis bfd	(Optional) Enables or disables BFD on a per-interface basis for one or more interfaces associated with the IS-IS routing process.  <b>Note</b> You should use the <b>disable</b> keyword only if you had earlier enabled BFD on all of the interfaces that IS-IS is associated with, using the <b>bfd all-interfaces</b> command in configuration mode.
<b>Step 9</b>	<b>end</b> <b>Example:</b>  Device(config-if)# end	Exits interface configuration mode and returns the router to privileged EXEC mode.
<b>Step 10</b>	<b>show bfd neighbors</b> [ <b>details</b> ] <b>Example:</b>  Device# show bfd neighbors details	(Optional) Displays information that can be used to verify if the BFD neighbor is active and displays the routing protocols that BFD has registered.
<b>Step 11</b>	<b>show clns interface</b> <b>Example:</b>  Device# show clns interface	(Optional) Displays information that can be used to verify if BFD for IS-IS has been enabled for a specific IS-IS interface that is associated.

### Configuring BFD Support for IS-IS for One or More Interfaces

To configure BFD for only one or more IS-IS interfaces, perform the steps in this section.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
	Device> enable	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>type number</i> <b>Example:</b> Device(config)# interface fastethernet 6/0	Enters interface configuration mode.
<b>Step 4</b>	<b>ip router isis</b> [ <i>tag</i> ] <b>Example:</b> Device(config-if)# ip router isis tag1	Enables support for IPv4 routing on the interface.
<b>Step 5</b>	<b>isis bfd</b> [disable] <b>Example:</b> Device(config-if)# isis bfd	Enables or disables BFD on a per-interface basis for one or more interfaces associated with the IS-IS routing process. <b>Note</b> You should use the <b>disable</b> keyword only if you enabled BFD on all of the interfaces that IS-IS is associated with using the <b>bfd all-interfaces</b> command in router configuration mode.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config-if)# end	Exits interface configuration mode and returns the router to privileged EXEC mode.
<b>Step 7</b>	<b>show bfd neighbors</b> [details] <b>Example:</b> Device# show bfd neighbors details	(Optional) Displays information that can help verify if the BFD neighbor is active and displays the routing protocols that BFD has registered.
<b>Step 8</b>	<b>show clns interface</b> <b>Example:</b> Device# show clns interface	(Optional) Displays information that can help verify if BFD for IS-IS has been enabled for a specific IS-IS interface that is associated.



## Configuring BFD Support for OSPF

This section describes the procedures for configuring BFD support for OSPF so that OSPF is a registered protocol with BFD and will receive forwarding path detection failure messages from BFD. You can either configure BFD support for OSPF globally on all interfaces or configure it selectively on one or more interfaces.

There are two methods for enabling BFD support for OSPF:

- You can enable BFD for all of the interfaces for which OSPF is routing by using the **bfd all-interfaces** command in router configuration mode. You can disable BFD support on individual interfaces using the **ip ospf bfd [disable]** command in interface configuration mode.
- You can enable BFD for a subset of the interfaces for which OSPF is routing by using the **ip ospf bfd** command in interface configuration mode.

See the following sections for tasks for configuring BFD support for OSPF:

### Configuring BFD Support for OSPF for All Interfaces

To configure BFD for all OSPF interfaces, perform the steps in this section.

If you do not want to configure BFD on all OSPF interfaces and would rather configure BFD support specifically for one or more interfaces, see the Configuring BFD Support for OSPF for One or More Interfaces section.

#### Before you begin

OSPF must be running on all participating routers.

The baseline parameters for BFD sessions on the interfaces over which you want to run BFD sessions to BFD neighbors must be configured. See the Configuring BFD Session Parameters on the Interface section for more information.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>router ospf <i>process-id</i></b> <b>Example:</b>  Device(config)# router ospf 4	Specifies an OSPF process and enters router configuration mode.
<b>Step 4</b>	<b>bfd all-interfaces</b> <b>Example:</b>	Enables BFD globally on all interfaces associated with the OSPF routing process.

	Command or Action	Purpose
	Device(config-router)# bfd all-interfaces	
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config-router)# exit	(Optional) Returns the device to global configuration mode. Enter this command only if you want to perform Step 7 to disable BFD for one or more interfaces.
<b>Step 6</b>	<b>interface</b> <i>type number</i> <b>Example:</b> Device(config)# interface fastethernet 6/0	(Optional) Enters interface configuration mode. Enter this command only if you want to perform Step 7 to disable BFD for one or more interfaces.
<b>Step 7</b>	<b>ip ospf bfd [disable]</b> <b>Example:</b> Device(config-if)# ip ospf bfd disable	(Optional) Disables BFD on a per-interface basis for one or more interfaces associated with the OSPF routing process. <b>Note</b> You should use the <b>disable</b> keyword only if you enabled BFD on all of the interfaces that OSPF is associated with using the <b>bfd all-interfaces</b> command in router configuration mode.
<b>Step 8</b>	<b>end</b> <b>Example:</b> Device(config-if)# end	Exits interface configuration mode and returns the router to privileged EXEC mode.
<b>Step 9</b>	<b>show bfd neighbors [details]</b> <b>Example:</b> Device# show bfd neighbors detail	(Optional) Displays information that can help verify if the BFD neighbor is active and displays the routing protocols that BFD has registered.
<b>Step 10</b>	<b>show ip ospf</b> <b>Example:</b> Device# show ip ospf	(Optional) Displays information that can help verify if BFD for OSPF has been enabled.

### Configuring BFD Support for OSPF for One or More Interfaces

To configure BFD on one or more OSPF interfaces, perform the steps in this section.

#### Before you begin

OSPF must be running on all participating routers.

The baseline parameters for BFD sessions on the interfaces over which you want to run BFD sessions to BFD neighbors must be configured. See the Configuring BFD Session Parameters on the Interface section for more information.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface type number</b> <b>Example:</b>  Device(config)# interface fastethernet 6/0	Enters interface configuration mode.
<b>Step 4</b>	<b>ip ospf bfd [disable]</b> <b>Example:</b>  Device(config-if)# ip ospf bfd	Enables or disables BFD on a per-interface basis for one or more interfaces associated with the OSPF routing process.  <b>Note</b> You should use the <b>disable</b> keyword only if you enabled BFD on all of the interfaces that OSPF is associated with using the <b>bfd all-interfaces</b> command in router configuration mode.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config-if)# end	Exits interface configuration mode and returns the router to privileged EXEC mode.
<b>Step 6</b>	<b>show bfd neighbors [details]</b> <b>Example:</b>  Device# show bfd neighbors details	(Optional) Displays information that can help verify if the BFD neighbor is active and displays the routing protocols that BFD has registered.
<b>Step 7</b>	<b>show ip ospf</b> <b>Example:</b>  Device# show ip ospf	(Optional) Displays information that can help verify if BFD support for OSPF has been enabled.

## Configuring BFD Support for HSRP

Perform this task to enable BFD support for Hot Standby Router Protocol (HSRP.) Repeat the steps in this procedure for each interface over which you want to run BFD sessions to HSRP peers.

HSRP supports BFD by default. If HSRP support for BFD has been manually disabled, you can reenable it at the router level to enable BFD support globally for all interfaces or on a per-interface basis at the interface level.

### Before you begin

- HSRP must be running on all participating routers.
- Cisco Express Forwarding must be enabled.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ip cef [distributed]</b> <b>Example:</b>  Device(config)# ip cef	Enables Cisco Express Forwarding or distributed Cisco Express Forwarding.
<b>Step 4</b>	<b>interface type number</b> <b>Example:</b>  Device(config)# interface FastEthernet 6/0	Enters interface configuration mode.
<b>Step 5</b>	<b>ip address ip-address mask</b> <b>Example:</b>  Device(config-if)# ip address 10.1.0.22 255.255.0.0	Configures an IP address for the interface.
<b>Step 6</b>	<b>standby [group-number] ip [ip-address [secondary]]</b> <b>Example:</b>  Device(config-if)# standby 1 ip 10.0.0.11	Activates HSRP.

	Command or Action	Purpose
<b>Step 7</b>	<b>standby bfd</b> <b>Example:</b>  Device(config-if)# standby bfd	(Optional) Enables HSRP support for BFD on the interface.
<b>Step 8</b>	<b>exit</b> <b>Example:</b>  Device(config-if)# exit	Exits interface configuration mode.
<b>Step 9</b>	<b>standby bfd all-interfaces</b> <b>Example:</b>  Device(config)# standby bfd all-interfaces	(Optional) Enables HSRP support for BFD on all interfaces.
<b>Step 10</b>	<b>exit</b> <b>Example:</b>  Device(config)# exit	Exits global configuration mode.
<b>Step 11</b>	<b>show standby neighbors</b> <b>Example:</b>  Device# show standby neighbors	(Optional) Displays information about HSRP support for BFD.

## Configuring BFD Support for Static Routing

Perform this task to configure BFD support for static routing. Repeat the steps in this procedure on each BFD neighbor. For more information, see the "Example: Configuring BFD Support for Static Routing" section.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>type number</i></b> <b>Example:</b>	Configures an interface and enters interface configuration mode.

	Command or Action	Purpose
	Device(config)# interface serial 2/0	
<b>Step 4</b>	<p>Perform one of the following steps:</p> <ul style="list-style-type: none"> <li>• <b>ip address</b> <i>ipv4-address mask</i></li> <li>• <b>ipv6 address</b> <i>ipv6-address/mask</i></li> </ul> <p><b>Example:</b></p> <p>Configuring an IPv4 address for the interface:</p> <pre>Device(config-if)# ip address 10.201.201.1 255.255.255.0</pre> <p>Configuring an IPv6 address for the interface:</p> <pre>Device(config-if)# ipv6 address 2001:db8:1:1::1/32</pre>	Configures an IP address for the interface.
<b>Step 5</b>	<p><b>bfd interval</b> <i>milliseconds</i> <b>min_rx</b> <i>milliseconds</i> <b>multiplier</b> <i>interval-multiplier</i></p> <p><b>Example:</b></p> <pre>Device(config-if)# bfd interval 500 min_rx 500 multiplier 5</pre>	<p>Enables BFD on the interface.</p> <p>The bfd interval configuration is removed when the subinterface on which it is configured is removed.</p> <p>The bfd interval configuration is not removed when:</p> <ul style="list-style-type: none"> <li>• an IPv4 address is removed from an interface</li> <li>• an IPv6 address is removed from an interface</li> <li>• IPv6 is disabled from an interface</li> <li>• an interface is shutdown</li> <li>• IPv4 CEF is disabled globally or locally on an interface</li> <li>• IPv6 CEF is disabled globally or locally on an interface</li> </ul>
<b>Step 6</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# exit</pre>	Exits interface configuration mode and returns to global configuration mode.
<b>Step 7</b>	<p><b>ip route static bfd</b> <i>interface-type interface-number ip-address</i> [<b>group</b> <i>group-name</i> [<b>passive</b>]]</p> <p><b>Example:</b></p>	<p>Specifies a static route BFD neighbor.</p> <ul style="list-style-type: none"> <li>• The <i>interface-type</i>, <i>interface-number</i>, and <i>ip-address</i> arguments are required because BFD support exists only for directly connected neighbors.</li> </ul>

	Command or Action	Purpose
	<pre>Device(config)# ip route static bfd TenGigabitEthernet1/0/1 10.10.10.2 group group1 passive</pre>	
<b>Step 8</b>	<p><b>ip route</b> [vrf vrf-name] prefix mask {ip-address   interface-type interface-number [ip-address]} [dhcp] [distance] [name next-hop-name] [permanent   track number] [tag tag]</p> <p><b>Example:</b></p> <pre>Device(config)# ip route 10.0.0.0 255.0.0.0</pre>	Specifies a static route BFD neighbor.
<b>Step 9</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config)# exit</pre>	Exits global configuration mode and returns to privileged EXEC mode.
<b>Step 10</b>	<p><b>show ip static route</b></p> <p><b>Example:</b></p> <pre>Device# show ip static route</pre>	(Optional) Displays static route database information.
<b>Step 11</b>	<p><b>show ip static route bfd</b></p> <p><b>Example:</b></p> <pre>Device# show ip static route bfd</pre>	(Optional) Displays information about the static BFD configuration from the configured BFD groups and nongroup entries.
<b>Step 12</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device# exit</pre>	Exits privileged EXEC mode and returns to user EXEC mode.

## Configuring BFD Echo Mode

BFD echo mode is enabled by default, but you can disable it such that it can run independently in each direction.

BFD echo mode works with asynchronous BFD. Echo packets are sent by the forwarding engine and forwarded back along the same path in order to perform detection--the BFD session at the other end does not participate in the actual forwarding of the echo packets. The echo function and the forwarding engine are responsible for the detection process; therefore, the number of BFD control packets that are sent out between two BFD neighbors is reduced. In addition, because the forwarding engine is testing the forwarding path on the remote (neighbor) system without involving the remote system, there is an opportunity to improve the interpacket delay variance, thereby achieving quicker failure detection times than when using BFD Version 0 with BFD control packets for the BFD session.

Echo mode is described as without asymmetry when it is running on both sides (both BFD neighbors are running echo mode).

## Prerequisites

BFD must be running on all participating routers.

Before using BFD echo mode, you must disable the sending of Internet Control Message Protocol (ICMP) redirect messages by entering the **no ip redirects** command, in order to avoid high CPU utilization.

The baseline parameters for BFD sessions on the interfaces over which you want to run BFD sessions to BFD neighbors must be configured. See the Configuring BFD Session Parameters on the Interface section for more information.

## Restrictions

BFD echo mode does not work in conjunction with Unicast Reverse Path Forwarding (uRPF) configuration. If BFD echo mode and uRPF configurations are enabled, then the sessions will flap.

## Disabling BFD Echo Mode Without Asymmetry

The steps in this procedure show how to disable BFD echo mode without asymmetry—no echo packets will be sent by the router, and the router will not forward BFD echo packets that are received from any neighbor routers.

Repeat the steps in this procedure for each BFD router.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Router# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>no bfd echo</b> <b>Example:</b> Router(config)# no bfd echo	Disables BFD echo mode. <ul style="list-style-type: none"> <li>• Use the <b>no</b> form to disable BFD echo mode.</li> </ul>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Router(config)# end	Exits global configuration mode and returns to privileged EXEC mode.

## Creating and Configuring BFD Templates

You can configure a single-hop template to specify a set of BFD interval values. BFD interval values specified as part of the BFD template are not specific to a single interface.





**Note** Configuring bfd-template will disable echo mode.

### Configuring a Single-Hop Template

Perform this task to create a BFD single-hop template and configure BFD interval timers.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>bfd-template single-hop <i>template-name</i></b> <b>Example:</b> Device(config)# bfd-template single-hop bfdtemplate1	Creates a single-hop BFD template and enters BFD configuration mode.
<b>Step 4</b>	<b>interval min-tx <i>milliseconds</i> min-rx <i>milliseconds</i> multiplier <i>multiplier-value</i></b> <b>Example:</b> Device(bfd-config)# interval min-tx 120 min-rx 100 multiplier 3	Configures the transmit and receive intervals between BFD packets, and specifies the number of consecutive BFD control packets that must be missed before BFD declares that a peer is unavailable.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(bfd-config)# end	Exits BFD configuration mode and returns the device to privileged EXEC mode.

## Monitoring and Troubleshooting BFD

This section describes how to retrieve BFD information for maintenance and troubleshooting. The commands in these tasks can be entered as needed, in any order desired.

This section contains information for monitoring and troubleshooting BFD for the following Cisco platforms:

### Monitoring and Troubleshooting BFD

To monitor or troubleshoot BFD on Cisco 7600 series routers, perform one or more of the steps in this section.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Router&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>show bfd neighbors [details]</b> <b>Example:</b> <pre>Router# show bfd neighbors details</pre>	(Optional) Displays the BFD adjacency database. <ul style="list-style-type: none"> <li>• The <b>details</b> keyword shows all BFD protocol parameters and timers per neighbor.</li> </ul>
<b>Step 3</b>	<b>debug bfd [packet   event]</b> <b>Example:</b> <pre>Router# debug bfd packet</pre>	(Optional) Displays debugging information about BFD packets.



## CHAPTER 92

# Configuring MSDP

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- [Finding Feature Information, on page 1525](#)
- [Information About Configuring MSDP, on page 1525](#)
- [How to Configure MSDP, on page 1528](#)
- [Monitoring and Maintaining MSDP, on page 1546](#)
- [Configuration Examples for Configuring MSDP, on page 1547](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Configuring MSDP

This section describes how to configure the Multicast Source Discovery Protocol (MSDP) on the switch. The MSDP connects multiple Protocol-Independent Multicast sparse-mode (PIM-SM) domains.

MSDP is not fully supported in this software release because of a lack of support for Multicast Border Gateway Protocol (MBGP), which works closely with MSDP. However, it is possible to create default peers that MSDP can operate with if MBGP is not running.



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**Note** To use this feature, the active switch must be running the IP services feature set.

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## MSDP Overview

MSDP allows multicast sources for a group to be known to all rendezvous points (RPs) in different domains. Each PIM-SM domain uses its own RPs and does not depend on RPs in other domains. An RP runs MSDP over the Transmission Control Protocol (TCP) to discover multicast sources in other domains.

An RP in a PIM-SM domain has an MSDP peering relationship with MSDP-enabled devices in another domain. The peering relationship occurs over a TCP connection, primarily exchanging a list of sources sending to multicast groups. The TCP connections between RPs are achieved by the underlying routing system. The receiving RP uses the source lists to establish a source path.

The purpose of this topology is to have domains discover multicast sources in other domains. If the multicast sources are of interest to a domain that has receivers, multicast data is delivered over the normal, source-tree building mechanism in PIM-SM. MSDP is also used to announce sources sending to a group. These announcements must originate at the domain's RP.

MSDP depends heavily on the Border Gateway Protocol (BGP) or MBGP for interdomain operation. We recommend that you run MSDP in RPs in your domain that are RPs for sources sending to global groups to be announced to the Internet.

## MSDP Operation

When a source sends its first multicast packet, the first-hop router (*designated router* or RP) directly connected to the source sends a PIM register message to the RP. The RP uses the register message to register the active source and to forward the multicast packet down the shared tree in the local domain. With MSDP configured, the RP also forwards a source-active (SA) message to all MSDP peers. The SA message identifies the source, the group the source is sending to, and the address of the RP or the originator ID (the IP address of the interface used as the RP address), if configured.

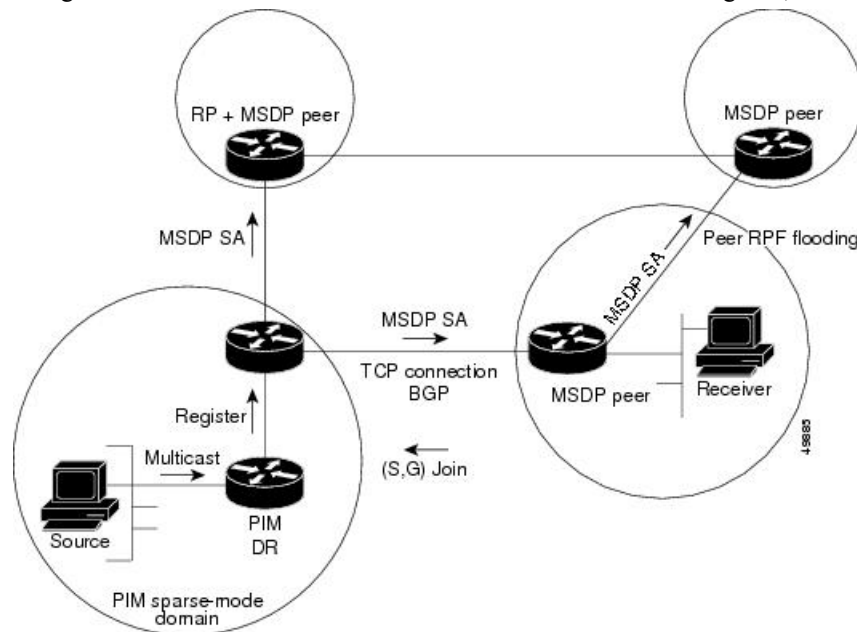
Each MSDP peer receives and forwards the SA message away from the originating RP to achieve peer reverse-path flooding (RPF). The MSDP device examines the BGP or MBGP routing table to discover which peer is the next hop toward the originating RP of the SA message. Such a peer is called an *RPF peer* (reverse-path forwarding peer). The MSDP device forwards the message to all MSDP peers other than the RPF peer. For information on how to configure an MSDP peer when BGP and MBGP are not supported, see the [Configuring a Default MSDP Peer, on page 1528](#).

If the MSDP peer receives the same SA message from a non-RPF peer toward the originating RP, it drops the message. Otherwise, it forwards the message to all its MSDP peers.

The RP for a domain receives the SA message from an MSDP peer. If the RP has any join requests for the group the SA message describes and if the (\*,G) entry exists with a nonempty outgoing interface list, the domain is interested in the group, and the RP triggers an (S,G) join toward the source. After the (S,G) join reaches the source's DR, a branch of the source tree has been built from the source to the RP in the remote domain. Multicast traffic can now flow from the source across the source tree to the RP and then down the shared tree in the remote domain to the receiver.

**Figure 96: MSDP Running Between RP Peers**

This figure shows MSDP operating between two MSDP peers. PIM uses MSDP as the standard mechanism to register a source with the RP of a domain. When MSDP is configured, this sequence occurs.



By default, the switch does not cache source or group pairs from received SA messages. When the switch forwards the MSDP SA information, it does not store it in memory. Therefore, if a member joins a group soon after an SA message is received by the local RP, that member needs to wait until the next SA message to hear about the source. This delay is known as join latency.

Local RPs can send SA requests and get immediate responses for all active sources for a given group. By default, the switch does not send any SA request messages to its MSDP peers when a new member joins a group and wants to receive multicast traffic. The new member waits to receive the next periodic SA message.

If you want a new member of a group to learn the active multicast sources in a connected PIM sparse-mode domain that are sending to a group, configure the switch to send SA request messages to the specified MSDP peer when a new member joins a group.

## MSDP Benefits

MSDP has these benefits:

- It breaks up the shared multicast distribution tree. You can make the shared tree local to your domain. Your local members join the local tree, and join messages for the shared tree never need to leave your domain.
- PIM sparse-mode domains can rely only on their own RPs, decreasing reliance on RPs in another domain. This increases security because you can prevent your sources from being known outside your domain.
- Domains with only receivers can receive data without globally advertising group membership.
- Global source multicast routing table state is not required, saving memory.

# How to Configure MSDP

## Default MSDP Configuration

MSDP is not enabled, and no default MSDP peer exists.

## Configuring a Default MSDP Peer

### Before you begin

Configure an MSDP peer.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp default-peer</b> <i>ip-address</i>   <i>name</i> [ <b>prefix-list</b> <i>list</i> ] <b>Example:</b> Router(config)# <b>ip msdp default-peer</b> <b>10.1.1.1 prefix-list site-a</b>	Defines a default peer from which to accept all MSDP SA messages. <ul style="list-style-type: none"> <li>• For <i>ip-address</i>   <i>name</i>, enter the IP address or Domain Name System (DNS) server name of the MSDP default peer.</li> <li>• (Optional) For <b>prefix-list</b> <i>list</i>, enter the list name that specifies the peer to be the default peer only for the listed prefixes. You can have multiple active default peers when you have a prefix list associated with each.</li> </ul> <p>When you enter multiple <b>ip msdp default-peer</b> commands with the <b>prefix-list</b> keyword, you use all the default peers at the same time for different RP prefixes. This syntax is typically used in a service provider cloud that connects stub site clouds.</p>

	Command or Action	Purpose
		When you enter multiple <b>ip msdp default-peer</b> commands without the <b>prefix-list</b> keyword, a single active peer accepts all SA messages. If that peer fails, the next configured default peer accepts all SA messages. This syntax is typically used at a stub site.
<b>Step 4</b>	<p><b>ip prefix-list</b> <i>name</i> [<b>description</b> <i>string</i>]   <b>seq number</b> {<b>permit</b>   <b>deny</b>} <i>network length</i></p> <p><b>Example:</b></p> <pre>Router(config)# ip prefix-list site-a seq 3 permit 12 network length 128</pre>	<p>(Optional) Creates a prefix list using the name specified in Step 2.</p> <ul style="list-style-type: none"> <li>• (Optional) For <b>description</b> <i>string</i>, enter a description of up to 80 characters to describe this prefix list.</li> <li>• For <b>seq number</b>, enter the sequence number of the entry. The range is 1 to 4294967294.</li> <li>• The <b>deny</b> keyword denies access to matching conditions.</li> <li>• The <b>permit</b> keyword permits access to matching conditions.</li> <li>• For <i>network length</i>, specify the network number and length (in bits) of the network mask that is permitted or denied.</li> </ul>
<b>Step 5</b>	<p><b>ip msdp description</b> {<i>peer-name</i>   <i>peer-address</i>} <i>text</i></p> <p><b>Example:</b></p> <pre>Router(config)# ip msdp description peer-name site-b</pre>	<p>(Optional) Configures a description for the specified peer to make it easier to identify in a configuration or in <b>show</b> command output.</p> <p>By default, no description is associated with an MSDP peer.</p>
<b>Step 6</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 7</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 8</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Device# <code>copy running-config startup-config</code>	

## Caching Source-Active State

If you want to sacrifice some memory in exchange for reducing the latency of the source information, you can configure the Device to cache SA messages. Perform the following steps to enable the caching of source/group pairs:

Follow these steps to enable the caching of source/group pairs:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp cache-sa-state</b> [ <i>list access-list-number</i> ] <b>Example:</b> Device(config)# <code>ip msdp cache-sa-state 100</code>	Enables the caching of source/group pairs (create an SA state). Those pairs that pass the access list are cached.  For <b>list</b> <i>access-list-number</i> , the range is 100 to 199.  <b>Note</b> An alternative to this command is the <b>ip msdp sa-reques</b> global configuration command, which causes the Device to send an SA request message to the MSDP peer when a new member for a group becomes active.
<b>Step 4</b>	<b>access-list</b> <i>access-list-number</i> { <b>deny</b>   <b>permit</b> } <i>protocol source source-wildcard destination destination-wildcard</i> <b>Example:</b> Device(config)# <code>access-list 100 permit</code>	Creates an IP extended access list, repeating the command as many times as necessary. <ul style="list-style-type: none"> <li>• For <i>access-list-number</i>, the range is 100 to 199. Enter the same number created in Step 2.</li> </ul>



	Command or Action	Purpose
	<pre>ip 171.69.0.0 0.0.255.255 224.2.0.0 0.0.255.255</pre>	<ul style="list-style-type: none"> <li>• The <b>deny</b> keyword denies access if the conditions are matched. The <b>permit</b> keyword permits access if the conditions are matched.</li> <li>• For <i>protocol</i>, enter <b>ip</b> as the protocol name.</li> <li>• For <i>source</i>, enter the number of the network or host from which the packet is being sent.</li> <li>• For <i>source-wildcard</i>, enter the wildcard bits in dotted decimal notation to be applied to the source. Place ones in the bit positions that you want to ignore.</li> <li>• For <i>destination</i>, enter the number of the network or host to which the packet is being sent.</li> <li>• For <i>destination-wildcard</i>, enter the wildcard bits in dotted decimal notation to be applied to the destination. Place ones in the bit positions that you want to ignore.</li> </ul> <p>Recall that the access list is always terminated by an implicit deny statement for everything.</p>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 7</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Controlling Source Information that Your Switch Originates

You can control the multicast source information that originates with your Device:

- Sources you advertise (based on your sources)
- Receivers of source information (based on knowing the requestor)

For more information, see the [Redistributing Sources, on page 1532](#) and the [Filtering Source-Active Request Messages, on page 1534](#).

## Redistributing Sources

SA messages originate on RPs to which sources have registered. By default, any source that registers with an RP is advertised. The *A flag* is set in the RP when a source is registered, which means the source is advertised in an SA unless it is filtered.

Follow these steps to further restrict which registered sources are advertised:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp redistribute</b> [ <b>list</b> <i>access-list-name</i> ] [ <b>asn</b> <i>aspath-access-list-number</i> ] [ <b>route-map</b> <i>map</i> ] <b>Example:</b> Device(config)# <b>ip msdp redistribute list 21</b>	Configures which (S,G) entries from the multicast routing table are advertised in SA messages. By default, only sources within the local domain are advertised. <ul style="list-style-type: none"> <li>• (Optional) <b>list</b> <i>access-list-name</i>— Enters the name or number of an IP standard or extended access list. The range is 1 to 99 for standard access lists and 100 to 199 for extended lists. The access list controls which local sources are advertised and to which groups they send.</li> <li>• (Optional) <b>asn</b> <i>aspath-access-list-number</i>—Enters the IP standard or extended access list number in the range 1 to 199. This access list number must also be configured in the <b>ip as-path access-list</b> command.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• (Optional) <b>route-map map</b>—Enters the IP standard or extended access list number in the range 1 to 199. This access list number must also be configured in the <b>ip as-path access-list</b> command.</li> </ul> <p>The Device advertises (S,G) pairs according to the access list or autonomous system path access list.</p>
<b>Step 4</b>	<p>Use one of the following:</p> <ul style="list-style-type: none"> <li>• <code>access-list <i>access-list-number</i> {deny   permit} <i>source</i> [<i>source-wildcard</i>]</code></li> <li>• <code>access-list <i>access-list-number</i> {deny   permit} <i>protocol source source-wildcard destination destination-wildcard</i></code></li> </ul> <p><b>Example:</b></p> <pre>Device(config)# access list 21 permit 194.1.22.0</pre> <p>or</p> <pre>Device(config)# access list 21 permit ip 194.1.22.0 1.1.1.1 194.3.44.0 1.1.1.1</pre>	<p>Creates an IP standard access list, repeating the command as many times as necessary.</p> <p>or</p> <p>Creates an IP extended access list, repeating the command as many times as necessary.</p> <ul style="list-style-type: none"> <li>• <i>access-list-number</i>—Enters the same number created in Step 2. The range is 1 to 99 for standard access lists and 100 to 199 for extended lists.</li> <li>• <b>deny</b>—Denies access if the conditions are matched. The <b>permit</b> keyword permits access if the conditions are matched.</li> <li>• <i>protocol</i>—Enters <b>ip</b> as the protocol name.</li> <li>• <i>source</i>—Enters the number of the network or host from which the packet is being sent.</li> <li>• <i>source-wildcard</i>—Enters the wildcard bits in dotted decimal notation to be applied to the source. Place ones in the bit positions that you want to ignore.</li> <li>• <i>destination</i>—Enters the number of the network or host to which the packet is being sent.</li> <li>• <i>destination-wildcard</i>—Enters the wildcard bits in dotted decimal notation to be applied to the destination. Place ones in the bit positions that you want to ignore.</li> </ul> <p>Recall that the access list is always terminated by an implicit deny statement for everything.</p>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p>	<p>Returns to privileged EXEC mode.</p>

	Command or Action	Purpose
	Device(config)# <b>end</b>	
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Filtering Source-Active Request Messages

By default, only Device that are caching SA information can respond to SA requests. By default, such a Device honors all SA request messages from its MSDP peers and supplies the IP addresses of the active sources.

However, you can configure the Device to ignore all SA requests from an MSDP peer. You can also honor only those SA request messages from a peer for groups described by a standard access list. If the groups in the access list pass, SA request messages are accepted. All other such messages from the peer for other groups are ignored.

To return to the default setting, use the **no ip msdp filter-sa-request** *{ip-address| name}* global configuration command.

Follow these steps to configure one of these options:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>ip msdp filter-sa-request</b> <i>{ip-addressname}</i></li> </ul>	Filters all SA request messages from the specified MSDP peer. or

	Command or Action	Purpose
	<ul style="list-style-type: none"> <li><code>ip msdp filter-sa-request {ip-addressname} list access-list-number</code></li> </ul> <p><b>Example:</b></p> <pre>Device(config)# ip msdp filter sa-request 171.69.2.2</pre>	Filters SA request messages from the specified MSDP peer for groups that pass the standard access list. The access list describes a multicast group address. The range for the access-list-number is 1 to 99.
<b>Step 4</b>	<p><code>access-list access-list-number {deny   permit} source [source-wildcard]</code></p> <p><b>Example:</b></p> <pre>Device(config)# access-list 1 permit 192.4.22.0 0.0.0.255</pre>	<p>Creates an IP standard access list, repeating the command as many times as necessary.</p> <ul style="list-style-type: none"> <li>For <i>access-list-number</i>, the range is 1 to 99.</li> <li>The <b>deny</b> keyword denies access if the conditions are matched. The <b>permit</b> keyword permits access if the conditions are matched.</li> <li>For <i>source</i>, enter the number of the network or host from which the packet is being sent.</li> <li>(Optional) For <i>source-wildcard</i>, enter the wildcard bits in dotted decimal notation to be applied to the source. Place ones in the bit positions that you want to ignore.</li> </ul> <p>Recall that the access list is always terminated by an implicit deny statement for everything.</p>
<b>Step 5</b>	<p><code>end</code></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<p><code>show running-config</code></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 7</b>	<p><code>copy running-config startup-config</code></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Controlling Source Information that Your Switch Forwards

By default, the Device forwards all SA messages it receives to all its MSDP peers. However, you can prevent outgoing messages from being forwarded to a peer by using a filter or by setting a time-to-live (TTL) value.

### Using a Filter

By creating a filter, you can perform one of these actions:

- Filter all source/group pairs
- Specify an IP extended access list to pass only certain source/group pairs
- Filter based on match criteria in a route map

Follow these steps to apply a filter:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>ip msdp sa-filter out</b>                {<i>ip-address name</i>}</li> <li>• <b>ip msdp sa-filter out</b>                {<i>ip-address name</i>}                list <i>access-list-number</i></li> <li>• <b>ip msdp sa-filter out</b>                {<i>ip-address name</i>}                route-map <i>map-tag</i></li> </ul> <b>Example:</b> Device(config)# <b>ip msdp sa-filter out</b> <b>switch.cisco.com</b> or	<ul style="list-style-type: none"> <li>• Filters all SA messages to the specified MSDP peer.</li> <li>• Passes only those SA messages that pass the IP extended access list to the specified peer. The range for the extended <i>access-list-number</i> is 100 to 199.</li> </ul> If both the <b>list</b> and the <b>route-map</b> keywords are used, all conditions must be true to pass any (S,G) pair in outgoing SA messages. <ul style="list-style-type: none"> <li>• Passes only those SA messages that meet the match criteria in the route map <i>map-tag</i> to the specified MSDP peer.</li> </ul> If all match criteria are true, a <b>permit</b> from the route map passes routes through the filter. A <b>deny</b> filters routes.

	Command or Action	Purpose
	<pre>Device(config)# ip msdp sa-filter out list 100</pre> <p>OR</p> <pre>Device(config)# ip msdp sa-filter out switch.cisco.com route-map 22</pre>	
<b>Step 4</b>	<p><b>access-list</b> <i>access-list-number</i> {deny   permit} <i>protocol source source-wildcard destination-wildcard</i></p> <p><b>Example:</b></p> <pre>Device(config)# access list 100 permit ip 194.1.22.0 1.1.1.1 194.3.44.0 1.1.1.1</pre>	<p>(Optional) Creates an IP extended access list, repeating the command as many times as necessary.</p> <ul style="list-style-type: none"> <li>• For <i>access-list-number</i>, enter the number specified in Step 2.</li> <li>• The <b>deny</b> keyword denies access if the conditions are matched. The <b>permit</b> keyword permits access if the conditions are matched.</li> <li>• For <i>protocol</i>, enter <b>ip</b> as the protocol name.</li> <li>• For <i>source</i>, enter the number of the network or host from which the packet is being sent.</li> <li>• For <i>source-wildcard</i>, enter the wildcard bits in dotted decimal notation to be applied to the source. Place ones in the bit positions that you want to ignore.</li> <li>• For <i>destination</i>, enter the number of the network or host to which the packet is being sent.</li> <li>• For <i>destination-wildcard</i>, enter the wildcard bits in dotted decimal notation to be applied to the destination. Place ones in the bit positions that you want to ignore.</li> </ul> <p>Recall that the access list is always terminated by an implicit deny statement for everything.</p>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p>	Verifies your entries.

	Command or Action	Purpose
	Device# <code>show running-config</code>	
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Using TTL to Limit the Multicast Data Sent in SA Messages

You can use a TTL value to control what data is encapsulated in the first SA message for every source. Only multicast packets with an IP-header TTL greater than or equal to the *tll* argument are sent to the specified MSDP peer. For example, you can limit internal traffic to a TTL of 8. If you want other groups to go to external locations, you must send those packets with a TTL greater than 8.

Follow these steps to establish a TTL threshold:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp ttl-threshold {ip-address   name} ttl</b> <b>Example:</b> Device(config)# <code>ip msdp ttl-threshold switch.cisco.com 0</code>	Limits which multicast data is encapsulated in the first SA message to the specified MSDP peer. <ul style="list-style-type: none"> <li>• For <i>ip-address   name</i>, enter the IP address or name of the MSDP peer to which the TTL limitation applies.</li> <li>• For <i>tll</i>, enter the TTL value. The default is 0, which means all multicast data packets are forwarded to the peer until the TTL is exhausted. The range is 0 to 255.</li> </ul>
<b>Step 4</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.



	Command or Action	Purpose
	Device(config)# <b>end</b>	
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Controlling Source Information that Your Switch Receives

By default, the Device receives all SA messages that its MSDP RPF peers send to it. However, you can control the source information that you receive from MSDP peers by filtering incoming SA messages. In other words, you can configure the Device to not accept them.

You can perform one of these actions:

- Filter all incoming SA messages from an MSDP peer
- Specify an IP extended access list to pass certain source/group pairs
- Filter based on match criteria in a route map

Follow these steps to apply a filter:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>ip msdp sa-filter in</b></li> </ul>	<ul style="list-style-type: none"> <li>• Filters all SA messages to the specified MSDP peer.</li> </ul>

	Command or Action	Purpose
	<pre>{ip-address name} • ip msdp sa-filter in  {ip-address name} list access-list-number • ip msdp sa-filter in  {ip-address name} route-map map-tag</pre> <p><b>Example:</b></p> <pre>Device(config)# ip msdp sa-filter in switch.cisco.com</pre> <p>OR</p> <pre>Device(config)# ip msdp sa-filter in list 100</pre> <p>OR</p> <pre>Device(config)# ip msdp sa-filter in switch.cisco.com route-map 22</pre>	<ul style="list-style-type: none"> <li>• Passes only those SA messages from the specified peer that pass the IP extended access list. The range for the extended <i>access-list-number</i> is 100 to 199.</li> </ul> <p>If both the <b>list</b> and the <b>route-map</b> keywords are used, all conditions must be true to pass any (S,G) pair in outgoing SA messages.</p> <ul style="list-style-type: none"> <li>• Passes only those SA messages from the specified MSDP peer that meet the match criteria in the route map <i>map-tag</i>.</li> </ul> <p>If all match criteria are true, a <b>permit</b> from the route map passes routes through the filter. A <b>deny</b> filters routes.</p>
<b>Step 4</b>	<pre><b>access-list</b> access-list-number {deny   permit} protocol source source-wildcard destination destination-wildcard</pre> <p><b>Example:</b></p> <pre>Device(config)# access list 100 permit ip 194.1.22.0 1.1.1.1 194.3.44.0 1.1.1.1</pre>	<p>(Optional) Creates an IP extended access list, repeating the command as many times as necessary.</p> <ul style="list-style-type: none"> <li>• <i>access-list-number</i>, enter the number specified in Step 2.</li> <li>• The <b>deny</b> keyword denies access if the conditions are matched. The <b>permit</b> keyword permits access if the conditions are matched.</li> <li>• For <i>protocol</i>, enter <b>ip</b> as the protocol name.</li> <li>• For <i>source</i>, enter the number of the network or host from which the packet is being sent.</li> <li>• For <i>source-wildcard</i>, enter the wildcard bits in dotted decimal notation to be applied to the source. Place ones in the bit positions that you want to ignore.</li> <li>• For <i>destination</i>, enter the number of the network or host to which the packet is being sent.</li> <li>• For <i>destination-wildcard</i>, enter the wildcard bits in dotted decimal notation to</li> </ul>

	Command or Action	Purpose
		<p>be applied to the destination. Place ones in the bit positions that you want to ignore.</p> <p>Recall that the access list is always terminated by an implicit deny statement for everything.</p>
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring an MSDP Mesh Group

An MSDP mesh group is a group of MSDP speakers that have fully meshed MSDP connectivity among one another. Any SA messages received from a peer in a mesh group are not forwarded to other peers in the same mesh group. Thus, you reduce SA message flooding and simplify peer-RPF flooding. Use the **ip msdp mesh-group** global configuration command when there are multiple RPs within a domain. It is especially used to send SA messages across a domain. You can configure multiple mesh groups (with different names) in a single Device.

Follow these steps to create a mesh group:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 3</b>	<p><b>ip msdp mesh-group</b> <i>name</i> {<i>ip-address</i>   <i>name</i>}</p> <p><b>Example:</b></p> <pre>Device(config)# ip msdp mesh-group 2 switch.cisco.com</pre>	<p>Configures an MSDP mesh group, and specifies the MSDP peer belonging to that mesh group.</p> <p>By default, the MSDP peers do not belong to a mesh group.</p> <ul style="list-style-type: none"> <li>• For <i>name</i>, enter the name of the mesh group.</li> <li>• For <i>ip-address</i>   <i>name</i>, enter the IP address or name of the MSDP peer to be a member of the mesh group.</li> </ul> <p>Repeat this procedure on each MSDP peer in the group.</p>
<b>Step 4</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 5</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 6</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Shutting Down an MSDP Peer

If you want to configure many MSDP commands for the same peer and you do not want the peer to become active, you can shut down the peer, configure it, and later bring it up. When a peer is shut down, the TCP connection is terminated and is not restarted. You can also shut down an MSDP session without losing configuration information for the peer.

Follow these steps to shut down a peer:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp shutdown</b> { <i>peer-name</i>   <i>peer address</i> } <b>Example:</b>  Device(config)# <b>ip msdp shutdown</b> <b>switch.cisco.com</b>	Shuts down the specified MSDP peer without losing configuration information.  For <i>peer-name</i>   <i>peer address</i> , enter the IP address or name of the MSDP peer to shut down.
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

## Including a Bordering PIM Dense-Mode Region in MSDP

You can configure MSDP on a Device that borders a PIM sparse-mode region with a dense-mode region. By default, active sources in the dense-mode region do not participate in MSDP.



**Note** We do not recommend using the **ip msdp border sa-address** global configuration command. It is better to configure the border router in the sparse-mode domain to proxy-register sources in the dense-mode domain to the RP of the sparse-mode domain and have the sparse-mode domain use standard MSDP procedures to advertise these sources.

The **ip msdp originator-id** global configuration command also identifies an interface to be used as the RP address. If both the **ip msdp border sa-address** and the **ip msdp originator-id** global configuration commands are configured, the address derived from the **ip msdp originator-id** command specifies the RP address.

Follow these steps to configure the border router to send SA messages for sources active in the dense-mode region to the MSDP peers:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp border sa-address</b> <i>interface-id</i> <b>Example:</b> Device(config)# <b>ip msdp border sa-address</b> 0/1	Configures the switch on the border between a dense-mode and sparse-mode region to send SA messages about active sources in the dense-mode region. For <i>interface-id</i> , specifies the interface from which the IP address is derived and used as the RP address in SA messages. The IP address of the interface is used as the Originator-ID, which is the RP field in the SA message.
<b>Step 4</b>	<b>ip msdp redistribute</b> [ <b>list</b> <i>access-list-name</i> ] [ <b>asn</b> <i>aspath-access-list-number</i> ] [ <b>route-map</b> <i>map</i> ] <b>Example:</b> Device(config)# <b>ip msdp redistribute list</b> 100	Configures which (S,G) entries from the multicast routing table are advertised in SA messages. For more information, see the <a href="#">Redistributing Sources, on page 1532</a> .

	Command or Action	Purpose
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring an Originating Address other than the RP Address

You can allow an MSDP speaker that originates an SA message to use the IP address of the interface as the RP address in the SA message by changing the Originator ID. You might change the Originator ID in one of these cases:

- If you configure a logical RP on multiple Device in an MSDP mesh group.
- If you have a Device that borders a PIM sparse-mode domain and a dense-mode domain. If a Device borders a dense-mode domain for a site, and sparse-mode is being used externally, you might want dense-mode sources to be known to the outside world. Because this Device is not an RP, it would not have an RP address to use in an SA message. Therefore, this command provides the RP address by specifying the address of the interface.

If both the **ip msdp border sa-address** and the **ip msdp originator-id** global configuration commands are configured, the address derived from the **ip msdp originator-id** command specifies the address of the RP.

Follow these steps to allow an MSDP speaker that originates an SA message to use the IP address on the interface as the RP address in the SA message:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>ip msdp originator-id <i>interface-id</i></b> <b>Example:</b>  Device(config)# <code>ip msdp originator-id 0/1</code>	Configures the RP address in SA messages to be the address of the originating device interface.  For <i>interface-id</i> , specify the interface on the local Device.
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b>  Device# <code>show running-config</code>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Monitoring and Maintaining MSDP

Commands that monitor MSDP SA messages, peers, state, and peer status:

*Table 107: Commands for Monitoring and Maintaining MSDP*

Command	Purpose
<code>debug ip msdp [peer-address   name] [detail] [routes]</code>	Debugs an MSDP activity.
<code>debug ip msdp resets</code>	Debugs MSDP peer reset reasons.



Command	Purpose
<b>show ip msdp count</b> [ <i>autonomous-system-number</i> ]	Displays the number of sources and groups originated in SA messages from each autonomous system. The <b>ip msdp cache-sa-state</b> command must be configured for this command to produce any output.
<b>show ip msdp peer</b> [ <i>peer-address</i>   <i>name</i> ]	Displays detailed information about an MSDP peer.
<b>show ip msdp sa-cache</b> [ <i>group-address</i>   <i>source-address</i>   <i>group-name</i>   <i>source-name</i> ] [ <i>autonomous-system-number</i> ]	Displays (S,G) state learned from MSDP peers.
<b>show ip msdp summary</b>	Displays MSDP peer status and SA message counts.

Commands that clear MSDP connections, statistics, and SA cache entries:

**Table 108: Commands for Clearing MSDP Connections, Statistics, or SA Cache Entries**

Command	Purpose
<b>clear ip msdp peer</b> <i>peer-address</i>   <i>name</i>	Clears the TCP connection to the specified MSDP peer, resetting all MSDP message counters.
<b>clear ip msdp statistics</b> [ <i>peer-address</i>   <i>name</i> ]	Clears statistics counters for one or all the MSDP peers without resetting the sessions.
<b>clear ip msdp sa-cache</b> [ <i>group-address</i>   <i>name</i> ]	Clears the SA cache entries for all entries, all sources for a specific group, or all entries for a specific source/group pair.

## Configuration Examples for Configuring MSDP

### Configuring a Default MSDP Peer: Example

This example shows a partial configuration of Router A and Router C in . Each of these ISPs have more than one customer (like the customer in ) who use default peering (no BGP or MBGP). In that case, they might have similar configurations. That is, they accept SAs only from a default peer if the SA is permitted by the corresponding prefix list.

Router A

```
Router(config)# ip msdp default-peer 10.1.1.1
Router(config)# ip msdp default-peer 10.1.1.1 prefix-list site-a
Router(config)# ip prefix-list site-b permit 10.0.0.0/1
```

Router C

```
Router(config)# ip msdp default-peer 10.1.1.1 prefix-list site-a
Router(config)# ip prefix-list site-b permit 10.0.0.0/1
```

## Caching Source-Active State: Example

This example shows how to enable the cache state for all sources in 171.69.0.0/16 sending to groups 224.2.0.0/16:

```
Device(config)# ip msdp cache-sa-state 100
Device(config)# access-list 100 permit ip 171.69.0.0 0.0.255.255 224.2.0.0 0.0.255.255
```

## Controlling Source Information that Your Switch Originates: Example

This example shows how to configure the switch to filter SA request messages from the MSDP peer at 171.69.2.2. SA request messages from sources on network 192.4.22.0 pass access list 1 and are accepted; all others are ignored.

```
Device(config)# ip msdp filter sa-request 171.69.2.2 list 1
Device(config)# access-list 1 permit 192.4.22.0 0.0.0.255
```

## Controlling Source Information that Your Switch Forwards: Example

This example shows how to allow only (S,G) pairs that pass access list 100 to be forwarded in an SA message to the peer named *switch.cisco.com*:

```
Device(config)# ip msdp peer switch.cisco.com connect-source gigabitethernet1/0/1
Device(config)# ip msdp sa-filter out switch.cisco.com list 100
Device(config)# access-list 100 permit ip 171.69.0.0 0.0.255.255 224.2.0.0 0.0.255.255
```

## Controlling Source Information that Your Switch Receives: Example

This example shows how to filter all SA messages from the peer named *switch.cisco.com*:

```
Device(config)# ip msdp peer switch.cisco.com connect-source gigabitethernet1/0/1
Device(config)# ip msdp sa-filter in switch.cisco.com
```



## CHAPTER 93

# Configuring IP Unicast Routing

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- [Information About Configuring IP Unicast Routing, on page 1550](#)
- [Information About IP Routing, on page 1550](#)
- [How to Configure IP Routing, on page 1557](#)
- [How to Configure IP Addressing, on page 1558](#)
- [Monitoring and Maintaining IP Addressing, on page 1577](#)
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- [Information About RIP, on page 1579](#)
- [How to Configure RIP, on page 1580](#)
- [Configuration Example for Summary Addresses and Split Horizon, on page 1587](#)
- [Information About OSPF, on page 1587](#)
- [How to Configure OSPF, on page 1591](#)
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- [Information About Multi-VRF CE, on page 1660](#)
- [How to Configure Multi-VRF CE, on page 1663](#)
- [Configuration Examples for Multi-VRF CE, on page 1677](#)
- [Configuring Unicast Reverse Path Forwarding, on page 1680](#)
- [Protocol-Independent Features, on page 1681](#)
- [Monitoring and Maintaining the IP Network, on page 1707](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Configuring IP Unicast Routing

This module describes how to configure IP Version 4 (IPv4) unicast routing on the switch.



**Note** On switches running the LAN base feature, static routing on VLANs is supported only with this release.

A switch stack operates and appears as a single router to the rest of the routers in the network. Basic routing functions like static routing and the Routing Information Protocol (RIP), are available with both the IP Base feature set and the IP Services feature set. To use advanced routing features and other routing protocols, you must have the IP Services feature set enabled on the standalone switch or on the active switch.



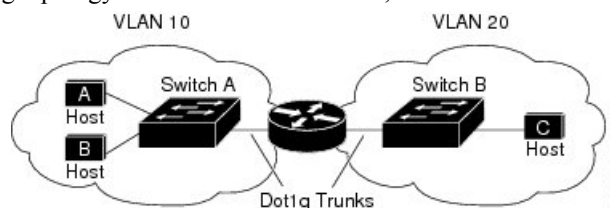
**Note** In addition to IPv4 traffic, you can also enable IP Version 6 (IPv6) unicast routing and configure interfaces to forward IPv6 traffic if the switch or switch stack is running the IP Base or IP Services feature set.

## Information About IP Routing

In some network environments, VLANs are associated with individual networks or subnetworks. In an IP network, each subnetwork is mapped to an individual VLAN. Configuring VLANs helps control the size of the broadcast domain and keeps local traffic local. However, network devices in different VLANs cannot communicate with one another without a Layer 3 device (router) to route traffic between the VLAN, referred to as inter-VLAN routing. You configure one or more routers to route traffic to the appropriate destination VLAN.

**Figure 97: Routing Topology Example**

This figure shows a basic routing topology. Switch A is in VLAN 10, and Switch B is in VLAN 20. The router



has an interface in each VLAN.

When Host A in VLAN 10 needs to communicate with Host B in VLAN 10, it sends a packet addressed to that host. Switch A forwards the packet directly to Host B, without sending it to the router.

When Host A sends a packet to Host C in VLAN 20, Switch A forwards the packet to the router, which receives the traffic on the VLAN 10 interface. The router checks the routing table, finds the correct outgoing interface, and forwards the packet on the VLAN 20 interface to Switch B. Switch B receives the packet and forwards it to Host C.

## Types of Routing

Routers and Layer 3 switches can route packets in these ways:

- By using default routing
- By using preprogrammed static routes for the traffic
- By dynamically calculating routes by using a routing protocol

Default routing refers to sending traffic with a destination unknown to the router to a default outlet or destination.

Static unicast routing forwards packets from predetermined ports through a single path into and out of a network. Static routing is secure and uses little bandwidth, but does not automatically respond to changes in the network, such as link failures, and therefore, might result in unreachable destinations. As networks grow, static routing becomes a labor-intensive liability.

Switches running the LAN base feature set support 16 user-configured static routes, in addition to any default routes used for the management interface. The LAN base image supports static routing only on SVIs.

Dynamic routing protocols are used by routers to dynamically calculate the best route for forwarding traffic. There are two types of dynamic routing protocols:

- Routers using distance-vector protocols maintain routing tables with distance values of networked resources, and periodically pass these tables to their neighbors. Distance-vector protocols use one or a series of metrics for calculating the best routes. These protocols are easy to configure and use.
- Routers using link-state protocols maintain a complex database of network topology, based on the exchange of link-state advertisements (LSAs) between routers. LSAs are triggered by an event in the network, which speeds up the convergence time or time required to respond to these changes. Link-state protocols respond quickly to topology changes, but require greater bandwidth and more resources than distance-vector protocols.

Distance-vector protocols supported by the switch are Routing Information Protocol (RIP), which uses a single distance metric (cost) to determine the best path and Border Gateway Protocol (BGP), which adds a path vector mechanism. The switch also supports the Open Shortest Path First (OSPF) link-state protocol and Enhanced IGRP (EIGRP), which adds some link-state routing features to traditional Interior Gateway Routing Protocol (IGRP) to improve efficiency.



---

**Note** On a switch or switch stack, the supported protocols are determined by the software running on the active switch. If the active switch is running the IP base feature set, only default routing, static routing and RIP are supported. If the switch is running the LAN base feature set, you can configure 16 static routes on SVIs. All other routing protocols require the IP services feature set.

---

## IP Routing and Switch Stacks

A switch stack appears to the network as a single switch, regardless of which switch in the stack is connected to a routing peer.

The active switch performs these functions:

- It initializes and configures the routing protocols.
- It sends routing protocol messages and updates to other routers.
- It processes routing protocol messages and updates received from peer routers.
- It generates, maintains, and distributes the distributed Cisco Express Forwarding (dCEF) database to all stack members. The routes are programmed on all switches in the stack bases on this database.
- The MAC address of the active switch is used as the router MAC address for the whole stack, and all outside devices use this address to send IP packets to the stack.
- All IP packets that require software forwarding or processing go through the CPU of the active switch.

Stack members perform these functions:

- They act as routing standby switches, ready to take over in case they are elected as the new active switch if the active switch fails.
- They program the routes into hardware.

If a active switch fails, the stack detects that the active switch is down and elects one of the stack members to be the new active switch. During this period, except for a momentary interruption, the hardware continues to forward packets with no active protocols.

However, even though the switch stack maintains the hardware identification after a failure, the routing protocols on the router neighbors might flap during the brief interruption before the active switch restarts. Routing protocols such as OSPF and EIGRP need to recognize neighbor transitions. The router uses two levels of nonstop forwarding (NSF) to detect a switchover, to continue forwarding network traffic, and to recover route information from peer devices:

- NSF-aware routers tolerate neighboring router failures. After the neighbor router restarts, an NSF-aware router supplies information about its state and route adjacencies on request.
- NSF-capable routers support NSF. When they detect a active switch change, they rebuild routing information from NSF-aware or NSF-capable neighbors and do not wait for a restart.

The switch stack supports NSF-capable routing for OSPF and EIGRP.

Upon election, the new active switch performs these functions:

- It starts generating, receiving, and processing routing updates.
- It builds routing tables, generates the CEF database, and distributes it to stack members.
- It uses its MAC address as the router MAC address. To notify its network peers of the new MAC address, it periodically (every few seconds for 5 minutes) sends a gratuitous ARP reply with the new router MAC address.



---

**Note** If you configure the persistent MAC address feature on the stack and the active switch changes, the stack MAC address does not change for the configured time period. If the previous active switch rejoins the stack as a member switch during that time period, the stack MAC address remains the MAC address of the previous active switch.

---

- It attempts to determine the reachability of every proxy ARP entry by sending an ARP request to the proxy ARP IP address and receiving an ARP reply. For each reachable proxy ARP IP address, it generates a gratuitous ARP reply with the new router MAC address. This process is repeated for 5 minutes after a new active switch election.



---

**Note** When a active switch is running the IP services feature set, the stack can run all supported protocols, including Open Shortest Path First (OSPF), and Enhanced IGRP (EIGRP) and Border Gateway Protocol (BGP). If the active switch fails and the new elected active switch is running the IP base or LAN base feature set, these protocols will no longer run in the stack.

---



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**Caution** Partitioning of the switch stack into two or more stacks might lead to undesirable behavior in the network.

---

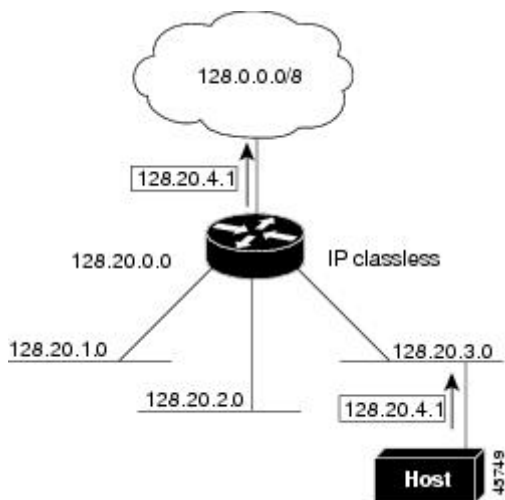
If the switch is reloaded, then all the ports on that switch go down and there is a loss of traffic for the interfaces involved in routing, despite NSF/SSO capability.

## Classless Routing

By default, classless routing behavior is enabled on the Device when it is configured to route. With classless routing, if a router receives packets for a subnet of a network with no default route, the router forwards the packet to the best supernet route. A supernet consists of contiguous blocks of Class C address spaces used to simulate a single, larger address space and is designed to relieve the pressure on the rapidly depleting Class B address space.

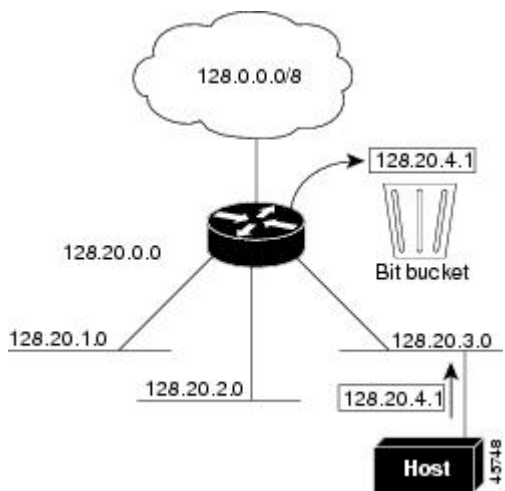
In the figure, classless routing is enabled. When the host sends a packet to 120.20.4.1, instead of discarding the packet, the router forwards it to the best supernet route. If you disable classless routing and a router receives packets destined for a subnet of a network with no network default route, the router discards the packet.

Figure 98: IP Classless Routing



In the figure, the router in network 128.20.0.0 is connected to subnets 128.20.1.0, 128.20.2.0, and 128.20.3.0. If the host sends a packet to 128.20.4.1, because there is no network default route, the router discards the packet.

Figure 99: No IP Classless Routing



To prevent the Device from forwarding packets destined for unrecognized subnets to the best supernet route possible, you can disable classless routing behavior.

## Address Resolution

You can control interface-specific handling of IP by using address resolution. A device using IP can have both a local address or MAC address, which uniquely defines the device on its local segment or LAN, and a network address, which identifies the network to which the device belongs.





**Note** In a switch stack, network communication uses a single MAC address and the IP address of the stack.

The local address or MAC address is known as a data link address because it is contained in the data link layer (Layer 2) section of the packet header and is read by data link (Layer 2) devices. To communicate with a device on Ethernet, the software must learn the MAC address of the device. The process of learning the MAC address from an IP address is called *address resolution*. The process of learning the IP address from the MAC address is called *reverse address resolution*.

The Device can use these forms of address resolution:

- Address Resolution Protocol (ARP) is used to associate IP address with MAC addresses. Taking an IP address as input, ARP learns the associated MAC address and then stores the IP address/MAC address association in an ARP cache for rapid retrieval. Then the IP datagram is encapsulated in a link-layer frame and sent over the network. Encapsulation of IP datagrams and ARP requests or replies on IEEE 802 networks other than Ethernet is specified by the Subnetwork Access Protocol (SNAP).
- Proxy ARP helps hosts with no routing tables learn the MAC addresses of hosts on other networks or subnets. If the Device (router) receives an ARP request for a host that is not on the same interface as the ARP request sender, and if the router has all of its routes to the host through other interfaces, it generates a proxy ARP packet giving its own local data link address. The host that sent the ARP request then sends its packets to the router, which forwards them to the intended host.

The Device also uses the Reverse Address Resolution Protocol (RARP), which functions the same as ARP does, except that the RARP packets request an IP address instead of a local MAC address. Using RARP requires a RARP server on the same network segment as the router interface. Use the **ip rarp-server address** interface configuration command to identify the server.

## Proxy ARP

Proxy ARP, the most common method for learning about other routes, enables an Ethernet host with no routing information to communicate with hosts on other networks or subnets. The host assumes that all hosts are on the same local Ethernet and that they can use ARP to learn their MAC addresses. If a Device receives an ARP request for a host that is not on the same network as the sender, the Device evaluates whether it has the best route to that host. If it does, it sends an ARP reply packet with its own Ethernet MAC address, and the host that sent the request sends the packet to the Device, which forwards it to the intended host. Proxy ARP treats all networks as if they are local, and performs ARP requests for every IP address.

## ICMP Router Discovery Protocol

Router discovery allows the Device to dynamically learn about routes to other networks using ICMP router discovery protocol (IRDP). IRDP allows hosts to locate routers. When operating as a client, the Device generates router discovery packets. When operating as a host, the Device receives router discovery packets. The Device can also listen to Routing Information Protocol (RIP) routing updates and use this information to infer locations of routers. The Device does not actually store the routing tables sent by routing devices; it merely keeps track of which systems are sending the data. The advantage of using IRDP is that it allows each router to specify both a priority and the time after which a device is assumed to be down if no further packets are received.

Each device discovered becomes a candidate for the default router, and a new highest-priority router is selected when a higher priority router is discovered, when the current default router is declared down, or when a TCP connection is about to time out because of excessive retransmissions.

## UDP Broadcast Packets and Protocols

User Datagram Protocol (UDP) is an IP host-to-host layer protocol, as is TCP. UDP provides a low-overhead, connectionless session between two end systems and does not provide for acknowledgment of received datagrams. Network hosts occasionally use UDP broadcasts to find address, configuration, and name information. If such a host is on a network segment that does not include a server, UDP broadcasts are normally not forwarded. You can remedy this situation by configuring an interface on a router to forward certain classes of broadcasts to a helper address. You can use more than one helper address per interface.

You can specify a UDP destination port to control which UDP services are forwarded. You can specify multiple UDP protocols. You can also specify the Network Disk (ND) protocol, which is used by older diskless Sun workstations and the network security protocol SDNS.

By default, both UDP and ND forwarding are enabled if a helper address has been defined for an interface.

## Broadcast Packet Handling

After configuring an IP interface address, you can enable routing and configure one or more routing protocols, or you can configure the way the Device responds to network broadcasts. A broadcast is a data packet destined for all hosts on a physical network. The Device supports two kinds of broadcasting:

- A directed broadcast packet is sent to a specific network or series of networks. A directed broadcast address includes the network or subnet fields.
- A flooded broadcast packet is sent to every network.



---

**Note** You can also limit broadcast, unicast, and multicast traffic on Layer 2 interfaces by using the **storm-control** interface configuration command to set traffic suppression levels.

---

Routers provide some protection from broadcast storms by limiting their extent to the local cable. Bridges (including intelligent bridges), because they are Layer 2 devices, forward broadcasts to all network segments, thus propagating broadcast storms. The best solution to the broadcast storm problem is to use a single broadcast address scheme on a network. In most modern IP implementations, you can set the address to be used as the broadcast address. Many implementations, including the one in the Device, support several addressing schemes for forwarding broadcast messages.

## IP Broadcast Flooding

You can allow IP broadcasts to be flooded throughout your internetwork in a controlled fashion by using the database created by the bridging STP. Using this feature also prevents loops. To support this capability, bridging must be configured on each interface that is to participate in the flooding. If bridging is not configured on an interface, it still can receive broadcasts. However, the interface never forwards broadcasts it receives, and the router never uses that interface to send broadcasts received on a different interface.

Packets that are forwarded to a single network address using the IP helper-address mechanism can be flooded. Only one copy of the packet is sent on each network segment.

To be considered for flooding, packets must meet these criteria. (Note that these are the same conditions used to consider packet forwarding using IP helper addresses.)

- The packet must be a MAC-level broadcast.
- The packet must be an IP-level broadcast.
- The packet must be a TFTP, DNS, Time, NetBIOS, ND, or BOOTP packet, or a UDP specified by the **ip forward-protocol udp** global configuration command.
- The time-to-live (TTL) value of the packet must be at least two.

A flooded UDP datagram is given the destination address specified with the **ip broadcast-address** interface configuration command on the output interface. The destination address can be set to any address. Thus, the destination address might change as the datagram propagates through the network. The source address is never changed. The TTL value is decremented.

When a flooded UDP datagram is sent out an interface (and the destination address possibly changed), the datagram is handed to the normal IP output routines and is, therefore, subject to access lists, if they are present on the output interface.

In the Device, the majority of packets are forwarded in hardware; most packets do not go through the Device CPU. For those packets that do go to the CPU, you can speed up spanning tree-based UDP flooding by a factor of about four to five times by using turbo-flooding. This feature is supported over Ethernet interfaces configured for ARP encapsulation.

## How to Configure IP Routing

By default, IP routing is disabled on the Device, and you must enable it before routing can take place.

In the following procedures, the specified interface must be one of these Layer 3 interfaces:

- A routed port: a physical port configured as a Layer 3 port by using the **no switchport** interface configuration command.
- A switch virtual interface (SVI): a VLAN interface created by using the **interface vlan *vlan\_id*** global configuration command and by default a Layer 3 interface.



---

**Note** On enabling ip routing, the VLAN configured as SVI will also learn broadcast ARP requests which are not self destined.

---

- An EtherChannel port channel in Layer 3 mode: a port-channel logical interface created by using the **interface port-channel *port-channel-number*** global configuration command and binding the Ethernet interface into the channel group.



---

**Note** The switch does not support tunnel interfaces for unicast routed traffic.

---

All Layer 3 interfaces on which routing will occur must have IP addresses assigned to them.



**Note** A Layer 3 switch can have an IP address assigned to each routed port and SVI.

The number of routed ports and SVIs that you can configure is limited to 128, exceeding the recommended number and volume of features being implemented might impact CPU utilization because of hardware limitations.

Configuring routing consists of several main procedures:

- To support VLAN interfaces, create and configure VLANs on the Device or switch stack, and assign VLAN membership to Layer 2 interfaces. For more information, see the "Configuring VLANs" chapter.
- Configure Layer 3 interfaces.
- Enable IP routing on the switch.
- Assign IP addresses to the Layer 3 interfaces.
- Enable selected routing protocols on the switch.
- Configure routing protocol parameters (optional).

## How to Configure IP Addressing

A required task for configuring IP routing is to assign IP addresses to Layer 3 network interfaces to enable the interfaces and allow communication with the hosts on those interfaces that use IP. The following sections describe how to configure various IP addressing features. Assigning IP addresses to the interface is required; the other procedures are optional.

- Default Addressing Configuration
- Assigning IP Addresses to Network Interfaces
- Configuring Address Resolution Methods
- Routing Assistance When IP Routing is Disabled
- Configuring Broadcast Packet Handling
- Monitoring and Maintaining IP Addressing

## Default IP Addressing Configuration

*Table 109: Default Addressing Configuration*

Feature	Default Setting
IP address	None defined.

Feature	Default Setting
ARP	No permanent entries in the Address Resolution Protocol (ARP) cache. Encapsulation: Standard Ethernet-style ARP. Timeout: 14400 seconds (4 hours).
IP broadcast address	255.255.255.255 (all ones).
IP classless routing	Enabled.
IP default gateway	Disabled.
IP directed broadcast	Disabled (all IP directed broadcasts are dropped).
IP domain	Domain list: No domain names defined. Domain lookup: Enabled. Domain name: Enabled.
IP forward-protocol	If a helper address is defined or User Datagram Protocol (UDP) flooding is configured, UDP forwarding is enabled on default ports. Any-local-broadcast: Disabled. Spanning Tree Protocol (STP): Disabled. Turbo-flood: Disabled.
IP helper address	Disabled.
IP host	Disabled.
IRDP	Disabled. Defaults when enabled: <ul style="list-style-type: none"> <li>• Broadcast IRDP advertisements.</li> <li>• Maximum interval between advertisements: 600 seconds.</li> <li>• Minimum interval between advertisements: 0.75 times max interval</li> <li>• Preference: 0.</li> </ul>
IP proxy ARP	Enabled.
IP routing	Disabled.
IP subnet-zero	Disabled.

## Assigning IP Addresses to Network Interfaces

An IP address identifies a location to which IP packets can be sent. Some IP addresses are reserved for special uses and cannot be used for host, subnet, or network addresses. RFC 1166, “Internet Numbers,” contains the official description of IP addresses.

An interface can have one primary IP address. A mask identifies the bits that denote the network number in an IP address. When you use the mask to subnet a network, the mask is referred to as a subnet mask. To receive an assigned network number, contact your Internet service provider.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device(config)# <b>interface</b> <b>gigabitethernet 1/0/1</b>	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
<b>Step 4</b>	<b>no switchport</b> <b>Example:</b>  Device(config-if)# <b>no switchport</b>	Removes the interface from Layer 2 configuration mode (if it is a physical interface).
<b>Step 5</b>	<b>ip address <i>ip-address subnet-mask</i></b> <b>Example:</b>  Device(config-if)# <b>ip address 10.1.5.1</b> <b>255.255.255.0</b>	Configures the IP address and IP subnet mask.
<b>Step 6</b>	<b>no shutdown</b> <b>Example:</b>  Device(config-if)# <b>no shutdown</b>	Enables the physical interface.
<b>Step 7</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	Device(config)# <b>end</b>	
<b>Step 8</b>	<b>show ip route</b> <b>Example:</b> Device# show ip route	Verifies your entries.
<b>Step 9</b>	<b>show ip interface [interface-id]</b> <b>Example:</b> Device# show ip interface gigabitethernet 1/0/1	Verifies your entries.
<b>Step 10</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config            startup-config</b>	(Optional) Saves your entries in the configuration file.

## Using Subnet Zero

Subnetting with a subnet address of zero is strongly discouraged because of the problems that can arise if a network and a subnet have the same addresses. For example, if network 131.108.0.0 is subnetted as 255.255.255.0, subnet zero would be written as 131.108.0.0, which is the same as the network address.

You can use the all ones subnet (131.108.255.0) and even though it is discouraged, you can enable the use of subnet zero if you need the entire subnet space for your IP address.

Use the **no ip subnet-zero** global configuration command to restore the default and disable the use of subnet zero.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>ip subnet-zero</b> <b>Example:</b>  Device(config)# <code>ip subnet-zero</code>	Enables the use of subnet zero for interface addresses and routing updates.
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b>  Device# <code>show running-config</code>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Disabling Classless Routing

To prevent the Device from forwarding packets destined for unrecognized subnets to the best supernet route possible, you can disable classless routing behavior.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.



	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 3</b>	<b>no ip classless</b> <b>Example:</b> Device(config)#no ip classless	Disables classless routing behavior.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b> Device# <code>show running-config</code>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring Address Resolution Methods

You can perform the following tasks to configure address resolution.

### Defining a Static ARP Cache

ARP and other address resolution protocols provide dynamic mapping between IP addresses and MAC addresses. Because most hosts support dynamic address resolution, you usually do not need to specify static ARP cache entries. If you must define a static ARP cache entry, you can do so globally, which installs a permanent entry in the ARP cache that the Device uses to translate IP addresses into MAC addresses. Optionally, you can also specify that the Device respond to ARP requests as if it were the owner of the specified IP address. If you do not want the ARP entry to be permanent, you can specify a timeout period for the ARP entry.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
	Device> <b>enable</b>	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>arp ip-address hardware-address type</b> <b>Example:</b> Device(config)# ip 10.1.5.1 c2f3.220a.12f4 arpa	Associates an IP address with a MAC (hardware) address in the ARP cache, and specifies encapsulation type as one of these: <ul style="list-style-type: none"> <li>• <b>arpa</b>—ARP encapsulation for Ethernet interfaces</li> <li>• <b>snap</b>—Subnetwork Address Protocol encapsulation for Token Ring and FDDI interfaces</li> <li>• <b>sap</b>—HP's ARP type</li> </ul>
<b>Step 4</b>	<b>arp ip-address hardware-address type [alias]</b> <b>Example:</b> Device(config)# ip 10.1.5.3 d7f3.220d.12f5 arpa alias	(Optional) Specifies that the switch respond to ARP requests as if it were the owner of the specified IP address.
<b>Step 5</b>	<b>interface interface-id</b> <b>Example:</b> Device(config)# interface gigabitethernet 1/0/1	Enters interface configuration mode, and specifies the interface to configure.
<b>Step 6</b>	<b>arp timeout seconds</b> <b>Example:</b> Device(config-if)# arp 20000	(Optional) Sets the length of time an ARP cache entry will stay in the cache. The default is 14400 seconds (4 hours). The range is 0 to 2147483 seconds.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show interfaces [interface-id]</b> <b>Example:</b> Device# show interfaces gigabitethernet 1/0/1	Verifies the type of ARP and the timeout value used on all interfaces or a specific interface.

	Command or Action	Purpose
<b>Step 9</b>	<b>show arp</b> <b>Example:</b>  Device# show arp	Views the contents of the ARP cache.
<b>Step 10</b>	<b>show ip arp</b> <b>Example:</b>  Device# show ip arp	Views the contents of the ARP cache.
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Setting ARP Encapsulation

By default, Ethernet ARP encapsulation (represented by the **arpa** keyword) is enabled on an IP interface. You can change the encapsulation methods to SNAP if required by your network.

To disable an encapsulation type, use the **no arp arpa** or **no arp snap** interface configuration command.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device(config)# interface gigabitethernet 1/0/2	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
<b>Step 4</b>	<b>arp {arpa   snap}</b> <b>Example:</b>	Specifies the ARP encapsulation method: <ul style="list-style-type: none"> <li>• <b>arpa</b>—Address Resolution Protocol</li> </ul>

	Command or Action	Purpose
	<code>Device(config-if)# arp arpa</code>	<ul style="list-style-type: none"> <li>• <b>snap</b>—Subnetwork Address Protocol</li> </ul>
<b>Step 5</b>	<b>end</b> <b>Example:</b> <code>Device(config)# end</code>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show interfaces</b> [ <i>interface-id</i> ] <b>Example:</b> <code>Device# show interfaces</code>	Verifies ARP encapsulation configuration on all interfaces or the specified interface.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> <code>Device# copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Enabling Proxy ARP

By default, the Device uses proxy ARP to help hosts learn MAC addresses of hosts on other networks or subnets.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <code>Device&gt; enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <code>Device# configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> <code>Device(config)# interface gigabitethernet 1/0/2</code>	Enters interface configuration mode, and specifies the Layer 3 interface to configure.

	Command or Action	Purpose
<b>Step 4</b>	<b>ip proxy-arp</b> <b>Example:</b>  Device(config-if)# ip proxy-arp	Enables proxy ARP on the interface.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config)# end	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show ip interface [interface-id]</b> <b>Example:</b>  Device# show ip interface gigabitethernet 1/0/2	Verifies the configuration on the interface or all interfaces.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Routing Assistance When IP Routing is Disabled

These mechanisms allow the Device to learn about routes to other networks when it does not have IP routing enabled:

- Proxy ARP
- Default Gateway
- ICMP Router Discovery Protocol (IRDP)

### Proxy ARP

Proxy ARP is enabled by default. To enable it after it has been disabled, see the “Enabling Proxy ARP” section. Proxy ARP works as long as other routers support it.

### Default Gateway

Another method for locating routes is to define a default router or default gateway. All non-local packets are sent to this router, which either routes them appropriately or sends an IP Control Message Protocol (ICMP) redirect message back, defining which local router the host should use. The Device caches the redirect messages and forwards each packet as efficiently as possible. A limitation of this method is that there is no means of detecting when the default router has gone down or is unavailable.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip default-gateway ip-address</b> <b>Example:</b> Device(config)# ip default gateway 10.1.5.1	Sets up a default gateway (router).
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show ip redirects</b> <b>Example:</b> Device# show ip redirects	Displays the address of the default gateway router to verify the setting.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config            startup-config</b>	(Optional) Saves your entries in the configuration file.

**ICMP Router Discovery Protocol (IRDP)**

The only required task for IRDP routing on an interface is to enable IRDP processing on that interface. When enabled, the default parameters apply.

You can optionally change any of these parameters. If you change the **maxadvertinterval** value, the **holdtime** and **minadvertinterval** values also change, so it is important to first change the **maxadvertinterval** value, before manually changing either the **holdtime** or **minadvertinterval** values.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# interface gigabitethernet 1/0/1	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
<b>Step 4</b>	<b>ip irdp</b> <b>Example:</b> Device(config-if)# ip irdp	Enables IRDP processing on the interface.
<b>Step 5</b>	<b>ip irdp multicast</b> <b>Example:</b> Device(config-if)# ip irdp multicast	(Optional) Sends IRDP advertisements to the multicast address (224.0.0.1) instead of IP broadcasts. <p><b>Note</b> This command allows for compatibility with Sun Microsystems Solaris, which requires IRDP packets to be sent out as multicasts. Many implementations cannot receive these multicasts; ensure end-host ability before using this command.</p>
<b>Step 6</b>	<b>ip irdp holdtime <i>seconds</i></b> <b>Example:</b> Device(config-if)# ip irdp holdtime 1000	(Optional) Sets the IRDP period for which advertisements are valid. The default is three times the <b>maxadvertinterval</b> value. It must be greater than <b>maxadvertinterval</b> and cannot be greater than 9000 seconds. If you change the <b>maxadvertinterval</b> value, this value also changes.

	Command or Action	Purpose
Step 7	<b>ip irdp maxadvertinterval</b> <i>seconds</i> <b>Example:</b> <pre>Device(config-if)# ip irdp maxadvertinterval 650</pre>	(Optional) Sets the IRDP maximum interval between advertisements. The default is 600 seconds.
Step 8	<b>ip irdp minadvertinterval</b> <i>seconds</i> <b>Example:</b> <pre>Device(config-if)# ip irdp minadvertinterval 500</pre>	(Optional) Sets the IRDP minimum interval between advertisements. The default is 0.75 times the <b>maxadvertinterval</b> . If you change the <b>maxadvertinterval</b> , this value changes to the new default (0.75 of <b>maxadvertinterval</b> ).
Step 9	<b>ip irdp preference</b> <i>number</i> <b>Example:</b> <pre>Device(config-if)# ip irdp preference 2</pre>	(Optional) Sets a device IRDP preference level. The allowed range is -231 to 231. The default is 0. A higher value increases the router preference level.
Step 10	<b>ip irdp address</b> <i>address [number]</i> <b>Example:</b> <pre>Device(config-if)# ip irdp address 10.1.10.10</pre>	(Optional) Specifies an IRDP address and preference to proxy-advertise.
Step 11	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
Step 12	<b>show ip irdp</b> <b>Example:</b> <pre>Device# show ip irdp</pre>	Verifies settings by displaying IRDP values.
Step 13	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring Broadcast Packet Handling

Perform the tasks in these sections to enable these schemes:

- Enabling Directed Broadcast-to-Physical Broadcast Translation
- Forwarding UDP Broadcast Packets and Protocols



- Establishing an IP Broadcast Address
- Flooding IP Broadcasts

## Enabling Directed Broadcast-to-Physical Broadcast Translation

By default, IP directed broadcasts are dropped; they are not forwarded. Dropping IP-directed broadcasts makes routers less susceptible to denial-of-service attacks.

You can enable forwarding of IP-directed broadcasts on an interface where the broadcast becomes a physical (MAC-layer) broadcast. Only those protocols configured by using the **ip forward-protocol** global configuration command are forwarded.

You can specify an access list to control which broadcasts are forwarded. When an access list is specified, only those IP packets permitted by the access list are eligible to be translated from directed broadcasts to physical broadcasts. For more information on access lists, see the “Configuring ACLs” chapter in the Security section.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# interface gigabitethernet 1/0/2	Enters interface configuration mode, and specifies the interface to configure.
<b>Step 4</b>	<b>ip directed-broadcast [<i>access-list-number</i>]</b> <b>Example:</b> Device(config-if)# ip directed-broadcast 103	Enables directed broadcast-to-physical broadcast translation on the interface. You can include an access list to control which broadcasts are forwarded. When an access list, only IP packets permitted by the access list can be translated.

	Command or Action	Purpose
		<p><b>Note</b> The <b>ip directed-broadcast</b> interface configuration command can be configured on a VPN routing/forwarding(VRF) interface and is VRF aware. Directed broadcast traffic is routed only within the VRF.</p>
<b>Step 5</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# exit</pre>	Returns to global configuration mode.
<b>Step 6</b>	<p><b>ip forward-protocol {udp [port]   nd   sdns}</b></p> <p><b>Example:</b></p> <pre>Device(config)# ip forward-protocol nd</pre>	<p>Specifies which protocols and ports the router forwards when forwarding broadcast packets.</p> <ul style="list-style-type: none"> <li>• <b>udp</b>—Forward UDP datagrams. port: (Optional) Destination port that controls which UDP services are forwarded.</li> <li>• <b>nd</b>—Forward ND datagrams.</li> <li>• <b>sdns</b>—Forward SDNS datagrams</li> </ul>
<b>Step 7</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 8</b>	<p><b>show ip interface [interface-id]</b></p> <p><b>Example:</b></p> <pre>Device# show ip interface</pre>	Verifies the configuration on the interface or all interfaces
<b>Step 9</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 10</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Forwarding UDP Broadcast Packets and Protocols

If you do not specify any UDP ports when you configure the forwarding of UDP broadcasts, you are configuring the router to act as a BOOTP forwarding agent. BOOTP packets carry DHCP information.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# interface gigabitethernet 1/0/1	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
<b>Step 4</b>	<b>ip helper-address <i>address</i></b> <b>Example:</b> Device(config-if)# ip helper address 10.1.10.1	Enables forwarding and specifies the destination address for forwarding UDP broadcast packets, including BOOTP.
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config-if)# exit	Returns to global configuration mode.
<b>Step 6</b>	<b>ip forward-protocol {udp [<i>port</i>]   nd   sdns}</b> <b>Example:</b> Device(config)# ip forward-protocol sdns	Specifies which protocols the router forwards when forwarding broadcast packets.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 8</b>	<b>show ip interface</b> <i>[interface-id]</i> <b>Example:</b> <pre>Device# show ip interface gigabitethernet 1/0/1</pre>	Verifies the configuration on the interface or all interfaces.
<b>Step 9</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 10</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Establishing an IP Broadcast Address

The most popular IP broadcast address (and the default) is an address consisting of all ones (255.255.255.255). However, the Device can be configured to generate any form of IP broadcast address.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> <pre>Device(config)# interface gigabitethernet 1/0/1</pre>	Enters interface configuration mode, and specifies the interface to configure.
<b>Step 4</b>	<b>ip broadcast-address</b> <i>ip-address</i> <b>Example:</b>	Enters a broadcast address different from the default, for example 128.1.255.255.

	Command or Action	Purpose
	Device(config-if)# ip broadcast-address 128.1.255.255	
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show ip interface</b> [ <i>interface-id</i> ] <b>Example:</b>  Device# show ip interface	Verifies the broadcast address on the interface or all interfaces.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Flooding IP Broadcasts

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip forward-protocol spanning-tree</b> <b>Example:</b>  Device(config)# ip forward-protocol spanning-tree	Uses the bridging spanning-tree database to flood UDP datagrams.
<b>Step 4</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	Device (config) # <b>end</b>	
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.
<b>Step 7</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 8</b>	<b>ip forward-protocol turbo-flood</b> <b>Example:</b> Device (config) # <b>ip forward-protocol turbo-flood</b>	Uses the spanning-tree database to speed up flooding of UDP datagrams.
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 10</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

# Monitoring and Maintaining IP Addressing

When the contents of a particular cache, table, or database have become or are suspected to be invalid, you can remove all its contents by using the **clear** privileged EXEC commands. The Table lists the commands for clearing contents.

**Table 110: Commands to Clear Caches, Tables, and Databases**

<b>clear arp-cache</b>	Clears the IP ARP cache and the fast-switching cache.
<b>clear host</b> { <i>name</i>   *}	Removes one or all entries from the hostname and the address cache.
<b>clear ip route</b> { <i>network</i> [ <i>mask</i> ]   *}	Removes one or more routes from the IP routing table.

You can display specific statistics, such as the contents of IP routing tables, caches, and databases; the reachability of nodes; and the routing path that packets are taking through the network. The Table lists the privileged EXEC commands for displaying IP statistics.

**Table 111: Commands to Display Caches, Tables, and Databases**

<b>show arp</b>	Displays the entries in the ARP table.
<b>show hosts</b>	Displays the default domain name, style of lookup service, name server hosts, and the cached list of hostnames and addresses.
<b>show ip aliases</b>	Displays IP addresses mapped to TCP ports (aliases).
<b>show ip arp</b>	Displays the IP ARP cache.
<b>show ip interface</b> [ <i>interface-id</i> ]	Displays the IP status of interfaces.
<b>show ip irdp</b>	Displays IRDP values.
<b>show ip masks</b> <i>address</i>	Displays the masks used for network addresses and the number of subnets using each mask.
<b>show ip redirects</b>	Displays the address of a default gateway.
<b>show ip route</b> [ <i>address</i> [ <i>mask</i> ]]   [ <i>protocol</i> ]	Displays the current state of the routing table.
<b>show ip route summary</b>	Displays the current state of the routing table in summary form.

# How to Configure IP Unicast Routing

## Enabling IP Unicast Routing

By default, the Device is in Layer 2 switching mode and IP routing is disabled. To use the Layer 3 capabilities of the Device, you must enable IP routing.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip routing</b> <b>Example:</b> Device(config)# <b>ip routing</b>	Enables IP routing.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.



## Example of Enabling IP Routing

This example shows how to enable IP routing using RIP as the routing protocol :

```
Device# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Device(config)# ip routing
Device(config)# router rip
Device(config-router)# network 10.0.0.0
Device(config-router)# end
```

## What to Do Next

You can now set up parameters for the selected routing protocols as described in these sections:

- RIP
- OSPF,
- EIGRP
- BGP
- Unicast Reverse Path Forwarding
- Protocol-Independent Features (optional)

## Information About RIP

The Routing Information Protocol (RIP) is an interior gateway protocol (IGP) created for use in small, homogeneous networks. It is a distance-vector routing protocol that uses broadcast User Datagram Protocol (UDP) data packets to exchange routing information. The protocol is documented in RFC 1058. You can find detailed information about RIP in *IP Routing Fundamentals*, published by Cisco Press.



---

**Note** RIP is supported in the IP Base Network Essentials feature set.

---

Using RIP, the Device sends routing information updates (advertisements) every 30 seconds. If a router does not receive an update from another router for 180 seconds or more, it marks the routes served by that router as unusable. If there is still no update after 240 seconds, the router removes all routing table entries for the non-updating router.

RIP uses hop counts to rate the value of different routes. The hop count is the number of routers that can be traversed in a route. A directly connected network has a hop count of zero; a network with a hop count of 16 is unreachable. This small range (0 to 15) makes RIP unsuitable for large networks.

If the router has a default network path, RIP advertises a route that links the router to the pseudonetwork 0.0.0.0. The 0.0.0.0 network does not exist; it is treated by RIP as a network to implement the default routing feature. The Device advertises the default network if a default was learned by RIP or if the router has a gateway of last resort and RIP is configured with a default metric. RIP sends updates to the interfaces in specified networks. If an interface's network is not specified, it is not advertised in any RIP update.

## Summary Addresses and Split Horizon

Routers connected to broadcast-type IP networks and using distance-vector routing protocols normally use the split-horizon mechanism to reduce the possibility of routing loops. Split horizon blocks information about routes from being advertised by a router on any interface from which that information originated. This feature usually optimizes communication among multiple routers, especially when links are broken.

## How to Configure RIP

### Default RIP Configuration

*Table 112: Default RIP Configuration*

Feature	Default Setting
Auto summary	Enabled.
Default-information originate	Disabled.
Default metric	Built-in; automatic metric translations.
IP RIP authentication key-chain	No authentication. Authentication mode: clear text.
IP RIP triggered	Disabled
IP split horizon	Varies with media.
Neighbor	None defined.
Network	None specified.
Offset list	Disabled.
Output delay	0 milliseconds.
Timers basic	<ul style="list-style-type: none"> <li>• Update: 30 seconds.</li> <li>• Invalid: 180 seconds.</li> <li>• Hold-down: 180 seconds.</li> <li>• Flush: 240 seconds.</li> </ul>
Validate-update-source	Enabled.
Version	Receives RIP Version 1 and 2 packets; sends Version 1 packets.

## Configuring Basic RIP Parameters

To configure RIP, you enable RIP routing for a network and optionally configure other parameters. On the Device, RIP configuration commands are ignored until you configure the network number.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip routing</b> <b>Example:</b> Device(config)# <b>ip routing</b>	Enables IP routing. (Required only if IP routing is disabled.)
<b>Step 4</b>	<b>router rip</b> <b>Example:</b> Device(config)# <b>router rip</b>	Enables a RIP routing process, and enter router configuration mode.
<b>Step 5</b>	<b>network <i>network number</i></b> <b>Example:</b> Device(config-router)# <b>network 12.0.0.0</b>	Associates a network with a RIP routing process. You can specify multiple <b>network</b> commands. RIP routing updates are sent and received through interfaces only on these networks. <p><b>Note</b> You must configure a network number for the RIP commands to take effect.</p>
<b>Step 6</b>	<b>neighbor <i>ip-address</i></b> <b>Example:</b> Device(config-router)# <b>neighbor 10.2.5.1</b>	(Optional) Defines a neighboring router with which to exchange routing information. This step allows routing updates from RIP (normally a broadcast protocol) to reach nonbroadcast networks.
<b>Step 7</b>	<b>offset-list [<i>access-list number</i>   <i>name</i>] {in   out} <i>offset</i> [<i>type number</i>]</b> <b>Example:</b>	(Optional) Applies an offset list to routing metrics to increase incoming and outgoing metrics to routes learned through RIP. You

	Command or Action	Purpose
	Device (config-router) # <b>offset-list 103 in 10</b>	can limit the offset list with an access list or an interface.
<b>Step 8</b>	<b>timers basic <i>update invalid holddown flush</i></b> <b>Example:</b> Device (config-router) # <b>timers basic 45 360 400 300</b>	(Optional) Adjusts routing protocol timers. Valid ranges for all timers are 0 to 4294967295 seconds. <ul style="list-style-type: none"> <li>• <i>update</i>—The time between sending routing updates. The default is 30 seconds.</li> <li>• <i>invalid</i>—The timer after which a route is declared invalid. The default is 180 seconds.</li> <li>• <i>holddown</i>—The time before a route is removed from the routing table. The default is 180 seconds.</li> <li>• <i>flush</i>—The amount of time for which routing updates are postponed. The default is 240 seconds.</li> </ul>
<b>Step 9</b>	<b>version {1   2}</b> <b>Example:</b> Device (config-router) # <b>version 2</b>	(Optional) Configures the switch to receive and send only RIP Version 1 or RIP Version 2 packets. By default, the switch receives Version 1 and 2 but sends only Version 1. You can also use the interface commands <b>ip rip {send   receive} version 1   2   1 2</b> to control what versions are used for sending and receiving on interfaces.
<b>Step 10</b>	<b>no auto summary</b> <b>Example:</b> Device (config-router) # <b>no auto summary</b>	(Optional) Disables automatic summarization. By default, the switch summarizes subprefixes when crossing classful network boundaries. Disable summarization (RIP Version 2 only) to advertise subnet and host routing information to classful network boundaries.
<b>Step 11</b>	<b>output-delay <i>delay</i></b> <b>Example:</b> Device (config-router) # <b>output-delay 8</b>	(Optional) Adds interpacket delay for RIP updates sent. By default, packets in a multiple-packet RIP update have no delay added between packets. If you are sending packets to a lower-speed device, you can add an interpacket delay in the range of 8 to 50 milliseconds.
<b>Step 12</b>	<b>end</b> <b>Example:</b> Device (config-router) # <b>end</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 13</b>	<b>show ip protocols</b> <b>Example:</b> Device# <code>show ip protocols</code>	Verifies your entries.
<b>Step 14</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring RIP Authentication

RIP Version 1 does not support authentication. If you are sending and receiving RIP Version 2 packets, you can enable RIP authentication on an interface. The key chain specifies the set of keys that can be used on the interface. If a key chain is not configured, no authentication is performed, not even the default.

The Device supports two modes of authentication on interfaces for which RIP authentication is enabled: plain text and MD5. The default is plain text.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <code>interface gigabitethernet 1/0/1</code>	Enters interface configuration mode, and specifies the interface to configure.
<b>Step 4</b>	<b>ip rip authentication key-chain <i>name-of-chain</i></b> <b>Example:</b> Device(config-if)# <code>ip rip authentication key-chain trees</code>	Enables RIP authentication.

	Command or Action	Purpose
<b>Step 5</b>	<b>ip rip authentication mode {text   md5}</b> <b>Example:</b>  Device(config-if)# ip rip authentication mode md5	Configures the interface to use plain text authentication (the default) or MD5 digest authentication.
<b>Step 6</b>	<b>end</b> <b>Example:</b>  Device(config)# end	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show running-config</b> <b>Example:</b>  Device# show running-config	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Configuring Summary Addresses and Split Horizon



**Note** In general, disabling split horizon is not recommended unless you are certain that your application requires it to properly advertise routes.

If you want to configure an interface running RIP to advertise a summarized local IP address pool on a network access server for dial-up clients, use the **ip summary-address rip** interface configuration command.



**Note** If split horizon is enabled, neither autosummary nor interface IP summary addresses are advertised.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
	Device> <b>enable</b>	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/1</b>	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
<b>Step 4</b>	<b>ip address <i>ip-address subnet-mask</i></b> <b>Example:</b> Device(config-if)# <b>ip address 10.1.1.10 255.255.255.0</b>	Configures the IP address and IP subnet.
<b>Step 5</b>	<b>ip summary-address rip ip address <i>ip-network mask</i></b> <b>Example:</b> Device(config-if)# <b>ip summary-address rip ip address 10.1.1.30 255.255.255.0</b>	Configures the IP address to be summarized and the IP network mask.
<b>Step 6</b>	<b>no ip split horizon</b> <b>Example:</b> Device(config-if)# <b>no ip split horizon</b>	Disables split horizon on the interface.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show ip interface <i>interface-id</i></b> <b>Example:</b> Device# <b>show ip interface gigabitethernet 1/0/1</b>	Verifies your entries.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Device# <code>copy running-config startup-config</code>	

## Configuring Split Horizon

Routers connected to broadcast-type IP networks and using distance-vector routing protocols normally use the split-horizon mechanism to reduce the possibility of routing loops. Split horizon blocks information about routes from being advertised by a router on any interface from which that information originated. This feature can optimize communication among multiple routers, especially when links are broken.



**Note** In general, we do not recommend disabling split horizon unless you are certain that your application requires it to properly advertise routes.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <code>interface gigabitethernet 1/0/1</code>	Enters interface configuration mode, and specifies the interface to configure.
<b>Step 4</b>	<b>ip address <i>ip-address subnet-mask</i></b> <b>Example:</b> Device(config-if)# <code>ip address 10.1.1.10 255.255.255.0</code>	Configures the IP address and IP subnet.
<b>Step 5</b>	<b>no ip split-horizon</b> <b>Example:</b> Device(config-if)# <code>no ip split-horizon</code>	Disables split horizon on the interface.



	Command or Action	Purpose
<b>Step 6</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show ip interface <i>interface-id</i></b> <b>Example:</b>  Device# show ip interface <b>gigabitethernet</b> <b>1/0/1</b>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuration Example for Summary Addresses and Split Horizon

In this example, the major net is 10.0.0.0. The summary address 10.2.0.0 overrides the autosummary address of 10.0.0.0 so that 10.2.0.0 is advertised out interface Gigabit Ethernet port 2, and 10.0.0.0 is not advertised. In the example, if the interface is still in Layer 2 mode (the default), you must enter a **no switchport** interface configuration command before entering the **ip address** interface configuration command.



**Note** If split horizon is enabled, neither autosummary nor interface summary addresses (those configured with the **ip summary-address rip** router configuration command) are advertised.

```
Device(config)# router rip
Device(config-router)# interface gigabitethernet1/0/2
Device(config-if)# ip address 10.1.5.1 255.255.255.0
Device(config-if)# ip summary-address rip 10.2.0.0 255.255.0.0
Device(config-if)# no ip split-horizon
Device(config-if)# exit
Device(config)# router rip
Device(config-router)# network 10.0.0.0
Device(config-router)# neighbor 2.2.2.2 peer-group mygroup
Device(config-router)# end
```

## Information About OSPF

OSPF is an Interior Gateway Protocol (IGP) designed expressly for IP networks, supporting IP subnetting and tagging of externally derived routing information. OSPF also allows packet authentication and uses IP

multicast when sending and receiving packets. The Cisco implementation supports RFC 1253, OSPF management information base (MIB).



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**Note** OSPF is supported in IP Base.

---

The Cisco implementation conforms to the OSPF Version 2 specifications with these key features:

- Definition of stub areas is supported.
- Routes learned through any IP routing protocol can be redistributed into another IP routing protocol. At the intradomain level, this means that OSPF can import routes learned through EIGRP and RIP. OSPF routes can also be exported into RIP.
- Plain text and MD5 authentication among neighboring routers within an area is supported.
- Configurable routing interface parameters include interface output cost, retransmission interval, interface transmit delay, router priority, router dead and hello intervals, and authentication key.
- Virtual links are supported.
- Not-so-stubby-areas (NSSAs) per RFC 1587 are supported.

OSPF typically requires coordination among many internal routers, area border routers (ABRs) connected to multiple areas, and autonomous system boundary routers (ASBRs). The minimum configuration would use all default parameter values, no authentication, and interfaces assigned to areas. If you customize your environment, you must ensure coordinated configuration of all routers.



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**Note** It is not recommended to use OSPF aggressive timers. An OSPF hello timer of less than five seconds is considered aggressive. OSPF and other routing protocols are handled at normal priority and sub second scheduling under high CPU usage conditions in not guaranteed.

BFD control packets are handled with high priority by a separate queue and bfd packets are processed in a high priority thread. BFD is preferred over OSPF for faster convergence.

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## OSPF Nonstop Forwarding

The Device or switch stack supports two levels of nonstop forwarding (NSF):

- [OSPF NSF Awareness, on page 1588](#)
- [OSPF NSF Capability, on page 1589](#)

### OSPF NSF Awareness

The IP-services feature set supports OSPF NSF Awareness for IPv4. When the neighboring router is NSF-capable, the Layer 3 Device continues to forward packets from the neighboring router during the interval between the primary Route Processor (RP) in a router crashing and the backup RP taking over, or while the primary RP is manually reloaded for a non-disruptive software upgrade.

This feature cannot be disabled.

## OSPF NSF Capability

The IP services feature set supports the OSPFv2 NSF IETF format in addition to the OSPFv2 NSF Cisco format that is supported in earlier releases. For information about this feature, see : *NSF—OSPF (RFC 3623 OSPF Graceful Restart)*.

The IP-services feature set also supports OSPF NSF-capable routing for IPv4 for better convergence and lower traffic loss following a stack master change. When a stack master change occurs in an OSPF NSF-capable stack, the new stack master must do two things to resynchronize its link-state database with its OSPF neighbors:

- Release the available OSPF neighbors on the network without resetting the neighbor relationship.
- Reacquire the contents of the link-state database for the network.

After a stack master change, the new master sends an OSPF NSF signal to neighboring NSF-aware devices. A device recognizes this signal to mean that it should not reset the neighbor relationship with the stack. As the NSF-capable stack master receives signals from other routes on the network, it begins to rebuild its neighbor list.

When the neighbor relationships are reestablished, the NSF-capable stack master resynchronizes its database with its NSF-aware neighbors, and routing information is exchanged between the OSPF neighbors. The new stack master uses this routing information to remove stale routes, to update the routing information database (RIB), and to update the forwarding information base (FIB) with the new information. The OSPF protocols then fully converge.

**Note**

OSPF NSF requires that all neighbor networking devices be NSF-aware. If an NSF-capable router discovers non-NSF aware neighbors on a network segment, it disables NSF capabilities for that segment. Other network segments where all devices are NSF-aware or NSF-capable continue to provide NSF capabilities.

Use the **nsf** OSPF routing configuration command to enable OSPF NSF routing. Use the **show ip ospf** privileged EXEC command to verify that it is enabled.

For more information, see *Cisco Nonstop Forwarding*:

[http://www.cisco.com/en/US/docs/ios/ha/configuration/guide/ha-nonstp\\_fwdg.html](http://www.cisco.com/en/US/docs/ios/ha/configuration/guide/ha-nonstp_fwdg.html)

## OSPF Area Parameters

You can optionally configure several OSPF area parameters. These parameters include authentication for password-based protection against unauthorized access to an area, stub areas, and not-so-stubby-areas (NSSAs). Stub areas are areas into which information on external routes is not sent. Instead, the area border router (ABR) generates a default external route into the stub area for destinations outside the autonomous system (AS). An NSSA does not flood all LSAs from the core into the area, but can import AS external routes within the area by redistribution.

Route summarization is the consolidation of advertised addresses into a single summary route to be advertised by other areas. If network numbers are contiguous, you can use the **area range** router configuration command to configure the ABR to advertise a summary route that covers all networks in the range.

## Other OSPF Parameters

You can optionally configure other OSPF parameters in router configuration mode.

- **Route summarization:** When redistributing routes from other protocols. Each route is advertised individually in an external LSA. To help decrease the size of the OSPF link state database, you can use the **summary-address** router configuration command to advertise a single router for all the redistributed routes included in a specified network address and mask.
- **Virtual links:** In OSPF, all areas must be connected to a backbone area. You can establish a virtual link in case of a backbone-continuity break by configuring two Area Border Routers as endpoints of a virtual link. Configuration information includes the identity of the other virtual endpoint (the other ABR) and the nonbackbone link that the two routers have in common (the transit area). Virtual links cannot be configured through a stub area.
- **Default route:** When you specifically configure redistribution of routes into an OSPF routing domain, the route automatically becomes an autonomous system boundary router (ASBR). You can force the ASBR to generate a default route into the OSPF routing domain.
- **Domain Name Server (DNS) names for use in all OSPF `show` privileged EXEC command displays** makes it easier to identify a router than displaying it by router ID or neighbor ID.
- **Default Metrics:** OSPF calculates the OSPF metric for an interface according to the bandwidth of the interface. The metric is calculated as  $ref-bw$  divided by bandwidth, where *ref* is 10 by default, and bandwidth (*bw*) is specified by the **bandwidth** interface configuration command. For multiple links with high bandwidth, you can specify a larger number to differentiate the cost on those links.
- **Administrative distance** is a rating of the trustworthiness of a routing information source, an integer between 0 and 255, with a higher value meaning a lower trust rating. An administrative distance of 255 means the routing information source cannot be trusted at all and should be ignored. OSPF uses three different administrative distances: routes within an area (interarea), routes to another area (interarea), and routes from another routing domain learned through redistribution (external). You can change any of the distance values.
- **Passive interfaces:** Because interfaces between two devices on an Ethernet represent only one network segment, to prevent OSPF from sending hello packets for the sending interface, you must configure the sending device to be a passive interface. Both devices can identify each other through the hello packet for the receiving interface.
- **Route calculation timers:** You can configure the delay time between when OSPF receives a topology change and when it starts the shortest path first (SPF) calculation and the hold time between two SPF calculations.
- **Log neighbor changes:** You can configure the router to send a syslog message when an OSPF neighbor state changes, providing a high-level view of changes in the router.

## LSA Group Pacing

The OSPF LSA group pacing feature allows the router to group OSPF LSAs and pace the refreshing, check-summing, and aging functions for more efficient router use. This feature is enabled by default with a 4-minute default pacing interval, and you will not usually need to modify this parameter. The optimum group pacing interval is inversely proportional to the number of LSAs the router is refreshing, check-summing, and aging. For example, if you have approximately 10,000 LSAs in the database, decreasing the pacing interval would benefit you. If you have a very small database (40 to 100 LSAs), increasing the pacing interval to 10 to 20 minutes might benefit you slightly.

## Loopback Interfaces

OSPF uses the highest IP address configured on the interfaces as its router ID. If this interface is down or removed, the OSPF process must recalculate a new router ID and resend all its routing information out its interfaces. If a loopback interface is configured with an IP address, OSPF uses this IP address as its router ID, even if other interfaces have higher IP addresses. Because loopback interfaces never fail, this provides greater stability. OSPF automatically prefers a loopback interface over other interfaces, and it chooses the highest IP address among all loopback interfaces.

## How to Configure OSPF

### Default OSPF Configuration

*Table 113: Default OSPF Configuration*

Feature	Default Setting
Interface parameters	Cost: 1. Retransmit interval: 5 seconds. Transmit delay: 1 second. Priority: 1. Hello interval: 10 seconds. Dead interval: 4 times the hello interval. No authentication. No password specified. MD5 authentication disabled.
Area	Authentication type: 0 (no authentication). Default cost: 1. Range: Disabled. Stub: No stub area defined. NSSA: No NSSA area defined.
Auto cost	100 Mb/s.
Default-information originate	Disabled. When enabled, the default metric setting is 10, and the external route type default is Type 2.
Default metric	Built-in, automatic metric translation, as appropriate for each routing protocol.

Feature	Default Setting
Distance OSPF	dist1 (all routes within an area): 110. dist2 (all routes from one area to another): 110. and dist3 (routes from other routing domains): 110.
OSPF database filter	Disabled. All outgoing link-state advertisements (LSAs) are flooded to the interface.
IP OSPF name lookup	Disabled.
Log adjacency changes	Enabled.
Neighbor	None specified.
Neighbor database filter	Disabled. All outgoing LSAs are flooded to the neighbor.
Network area	Disabled.
Nonstop Forwarding (NSF) awareness	Enabled. Allows Layer 3 switches to continue forwarding packets from a neighboring NSF-capable router during hardware or software changes.
NSF capability	Disabled. <b>Note</b> The switch stack supports OSPF NSF-capable routing for IPv4.
Router ID	No OSPF routing process defined.
Summary address	Disabled.
Timers LSA group pacing	240 seconds.
Timers shortest path first (spf)	spf delay: 5 seconds.; spf-holdtime: 10 seconds.
Virtual link	No area ID or router ID defined. Hello interval: 10 seconds. Retransmit interval: 5 seconds. Transmit delay: 1 second. Dead interval: 40 seconds. Authentication key: no key predefined. Message-digest key (MD5): no key predefined.

## Configuring Basic OSPF Parameters

To enable OSPF, create an OSPF routing process, specify the range of IP addresses to associate with the routing process, and assign area IDs to be associated with that range. For switches running the IP services image, you can configure either the Cisco OSPFv2 NSF format or the IETF OSPFv2 NSF format.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>router ospf process-id</b> <b>Example:</b> Device(config)# <code>router ospf 15</code>	Enables OSPF routing, and enter router configuration mode. The process ID is an internally used identification parameter that is locally assigned and can be any positive integer. Each OSPF routing process has a unique value.  <b>Note</b> OSPF for Routed Access supports only one OSPFv2 and one OSPFv3 instance with a maximum number of 1000 dynamically learned routes.
<b>Step 3</b>	<b>nsf cisco [enforce global]</b> <b>Example:</b> Device(config)# <code>nsf cisco enforce global</code>	(Optional) Enables Cisco NSF operations for OSPF. The <b>enforce global</b> keyword cancels NSF restart when non-NSF-aware neighboring networking devices are detected.  <b>Note</b> Enter the command in Step 3 or Step 4, and go to Step 5.
<b>Step 4</b>	<b>nsf ietf [restart-interval seconds]</b> <b>Example:</b> Device(config)# <code>nsf ietf restart-interval 60</code>	(Optional) Enables IETF NSF operations for OSPF. The <b>restart-interval</b> keyword specifies the length of the graceful restart interval, in seconds. The range is from 1 to 1800. The default is 120.  <b>Note</b> Enter the command in Step 3 or Step 4, and go to Step 5.
<b>Step 5</b>	<b>network address wildcard-mask area area-id</b> <b>Example:</b> Device(config)# <code>network 10.1.1.1 255.240.0.0 area 20</code>	Define an interface on which OSPF runs and the area ID for that interface. You can use the wildcard-mask to use a single command to define one or more multiple interfaces to be associated with a specific OSPF area. The area ID can be a decimal value or an IP address.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 7</b>	<b>show ip protocols</b> <b>Example:</b> Device# <code>show ip protocols</code>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring OSPF Interfaces

You can use the `ip ospf` interface configuration commands to modify interface-specific OSPF parameters. You are not required to modify any of these parameters, but some interface parameters (hello interval, dead interval, and authentication key) must be consistent across all routers in an attached network. If you modify these parameters, be sure all routers in the network have compatible values.



**Note** The `ip ospf` interface configuration commands are all optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>interface interface-id</b> <b>Example:</b> Device(config)# <code>interface gigabitethernet 1/0/1</code>	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
<b>Step 3</b>	<b>ip ospf cost</b> <b>Example:</b> Device(config-if)# <code>ip ospf 8</code>	(Optional) Explicitly specifies the cost of sending a packet on the interface.
<b>Step 4</b>	<b>ip ospf retransmit-interval seconds</b> <b>Example:</b>	(Optional) Specifies the number of seconds between link state advertisement transmissions. The range is 1 to 65535 seconds. The default is 5 seconds.



	Command or Action	Purpose
	Device(config-if)# ip ospf transmit-interval 10	
<b>Step 5</b>	<b>ip ospf transmit-delay</b> seconds <b>Example:</b>  Device(config-if)# ip ospf transmit-delay 2	(Optional) Sets the estimated number of seconds to wait before sending a link state update packet. The range is 1 to 65535 seconds. The default is 1 second.
<b>Step 6</b>	<b>ip ospf priority</b> number <b>Example:</b>  Device(config-if)# ip ospf priority 5	(Optional) Sets priority to help find the OSPF designated router for a network. The range is from 0 to 255. The default is 1.
<b>Step 7</b>	<b>ip ospf hello-interval</b> seconds <b>Example:</b>  Device(config-if)# ip ospf hello-interval 12	(Optional) Sets the number of seconds between hello packets sent on an OSPF interface. The value must be the same for all nodes on a network. The range is 1 to 65535 seconds. The default is 10 seconds.
<b>Step 8</b>	<b>ip ospf dead-interval</b> seconds <b>Example:</b>  Device(config-if)# ip ospf dead-interval 8	(Optional) Sets the number of seconds after the last device hello packet was seen before its neighbors declare the OSPF router to be down. The value must be the same for all nodes on a network. The range is 1 to 65535 seconds. The default is 4 times the hello interval.
<b>Step 9</b>	<b>ip ospf authentication-key</b> key <b>Example:</b>  Device(config-if)# ip ospf authentication-key password	(Optional) Assign a password to be used by neighboring OSPF routers. The password can be any string of keyboard-entered characters up to 8 bytes in length. All neighboring routers on the same network must have the same password to exchange OSPF information.
<b>Step 10</b>	<b>ip ospf message digest-key</b> keyid <b>md5</b> key <b>Example:</b>  Device(config-if)# ip ospf message digest-key 16 md5 yourlpass	(Optional) Enables MDS authentication. <ul style="list-style-type: none"> <li>• <i>keyid</i>—An identifier from 1 to 255.</li> <li>• <i>key</i>—An alphanumeric password of up to 16 bytes.</li> </ul>
<b>Step 11</b>	<b>ip ospf database-filter all out</b> <b>Example:</b>  Device(config-if)# ip ospf database-filter all out	(Optional) Block flooding of OSPF LSA packets to the interface. By default, OSPF floods new LSAs over all interfaces in the same area, except the interface on which the LSA arrives.
<b>Step 12</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	Device(config)# <b>end</b>	
<b>Step 13</b>	<b>show ip ospf interface</b> [ <i>interface-name</i> ] <b>Example:</b> Device# show ip ospf interface	Displays OSPF-related interface information.
<b>Step 14</b>	<b>show ip ospf neighbor detail</b> <b>Example:</b> Device# show ip ospf neighbor detail	Displays NSF awareness status of neighbor switch. The output matches one of these examples: <ul style="list-style-type: none"> <li>• <i>Options is 0x52</i> <i>LLS Options is 0x1 (LR)</i> When both of these lines appear, the neighbor switch is NSF aware.</li> <li>• <i>Options is 0x42</i>—This means the neighbor switch is not NSF aware.</li> </ul>
<b>Step 15</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Configuring OSPF Area Parameters

### Before you begin



**Note** The OSPF **area** router configuration commands are all optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>router ospf process-id</b> <b>Example:</b>  Device(config)# router ospf 109	Enables OSPF routing, and enter router configuration mode.
<b>Step 3</b>	<b>area area-id authentication</b> <b>Example:</b>  Device(config-router)# area 1 authentication	(Optional) Allow password-based protection against unauthorized access to the identified area. The identifier can be either a decimal value or an IP address.
<b>Step 4</b>	<b>area area-id authentication message-digest</b> <b>Example:</b>  Device(config-router)# area 1 authentication message-digest	(Optional) Enables MD5 authentication on the area.
<b>Step 5</b>	<b>area area-id stub [no-summary]</b> <b>Example:</b>  Device(config-router)# area 1 stub	(Optional) Define an area as a stub area. The <b>no-summary</b> keyword prevents an ABR from sending summary link advertisements into the stub area.
<b>Step 6</b>	<b>area area-id nssa [no-redistribution] [default-information-originate] [no-summary]</b> <b>Example:</b>  Device(config-router)# area 1 nssa default-information-originate	(Optional) Defines an area as a not-so-stubby-area. Every router within the same area must agree that the area is NSSA. Select one of these keywords: <ul style="list-style-type: none"> <li>• <b>no-redistribution</b>—Select when the router is an NSSA ABR and you want the <b>redistribute</b> command to import routes into normal areas, but not into the NSSA.</li> <li>• <b>default-information-originate</b>—Select on an ABR to allow importing type 7 LSAs into the NSSA.</li> <li>• <b>no-redistribution</b>—Select to not send summary LSAs into the NSSA.</li> </ul>
<b>Step 7</b>	<b>area area-id range address mask</b> <b>Example:</b>  Device(config-router)# area 1 range 255.240.0.0	(Optional) Specifies an address range for which a single route is advertised. Use this command only with area border routers.
<b>Step 8</b>	<b>end</b> <b>Example:</b>  Device(config)# end	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 9</b>	<b>show ip ospf</b> [ <i>process-id</i> ] <b>Example:</b>  Device# show ip ospf	Displays information about the OSPF routing process in general or for a specific process ID to verify configuration.
<b>Step 10</b>	<b>show ip ospf</b> [ <i>process-id</i> [ <i>area-id</i> ]] <b>database</b> <b>Example:</b>  Device# show ip ospf database	Displays lists of information related to the OSPF database for a specific router.
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Configuring Other OSPF Parameters

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>router ospf</b> <i>process-id</i> <b>Example:</b>  Device(config)# router ospf 10	Enables OSPF routing, and enter router configuration mode.
<b>Step 3</b>	<b>summary-address</b> <i>address mask</i> <b>Example:</b>  Device(config)# summary-address 10.1.1.1 255.255.255.0	(Optional) Specifies an address and IP subnet mask for redistributed routes so that only one summary route is advertised.
<b>Step 4</b>	<b>area</b> <i>area-id</i> <b>virtual-link</b> <i>router-id</i> [ <b>hello-interval</b> <i>seconds</i> ] [ <b>retransmit-interval</b> <i>seconds</i> ] [ <b>trans</b> ] [[ <b>authentication-key</b> <i>key</i> ]   <b>message-digest-key</b> <i>keyid md5 key</i> ]] <b>Example:</b>	(Optional) Establishes a virtual link and set its parameters.

	Command or Action	Purpose
	<pre>Device(config)# area 2 virtual-link 192.168.255.1 hello-interval 5</pre>	
<b>Step 5</b>	<p><b>default-information originate</b> [always] [metric <i>metric-value</i>] [metric-type <i>type-value</i>] [route-map <i>map-name</i>]</p> <p><b>Example:</b></p> <pre>Device(config)# default-information originate metric 100 metric-type 1</pre>	(Optional) Forces the ASBR to generate a default route into the OSPF routing domain. Parameters are all optional.
<b>Step 6</b>	<p><b>ip ospf name-lookup</b></p> <p><b>Example:</b></p> <pre>Device(config)# ip ospf name-lookup</pre>	(Optional) Configures DNS name lookup. The default is disabled.
<b>Step 7</b>	<p><b>ip auto-cost reference-bandwidth</b> <i>ref-bw</i></p> <p><b>Example:</b></p> <pre>Device(config)# ip auto-cost reference-bandwidth 5</pre>	(Optional) Specifies an address range for which a single route will be advertised. Use this command only with area border routers.
<b>Step 8</b>	<p><b>distance ospf</b> {[inter-area <i>dist1</i>] [inter-area <i>dist2</i>] [external <i>dist3</i>]}</p> <p><b>Example:</b></p> <pre>Device(config)# distance ospf inter-area 150</pre>	(Optional) Changes the OSPF distance values. The default distance for each type of route is 110. The range is 1 to 255.
<b>Step 9</b>	<p><b>passive-interface</b> <i>type number</i></p> <p><b>Example:</b></p> <pre>Device(config)# passive-interface gigabitethernet 1/0/6</pre>	(Optional) Suppresses the sending of hello packets through the specified interface.
<b>Step 10</b>	<p><b>timers throttle spf</b> <i>spf-delay</i> <i>spf-holdtime</i> <i>spf-wait</i></p> <p><b>Example:</b></p> <pre>Device(config)# timers throttle spf 200 100 100</pre>	(Optional) Configures route calculation timers. <ul style="list-style-type: none"> <li>• <i>spf-delay</i>—Delay between receiving a change to SPF calculation. The range is from 1 to 600000 milliseconds.</li> <li>• <i>spf-holdtime</i>—Delay between first and second SPF calculation. The range is from 1 to 600000 in milliseconds.</li> <li>• <i>spf-wait</i>—Maximum wait time in milliseconds for SPF calculations. The range is from 1 to 600000 in milliseconds.</li> </ul>

	Command or Action	Purpose
<b>Step 11</b>	<b>ospf log-adj-changes</b> <b>Example:</b>  Device(config)# ospf log-adj-changes	(Optional) Sends syslog message when a neighbor state changes.
<b>Step 12</b>	<b>end</b> <b>Example:</b>  Device(config)# end	Returns to privileged EXEC mode.
<b>Step 13</b>	<b>show ip ospf [process-id [area-id]] database</b> <b>Example:</b>  Device# show ip ospf database	Displays lists of information related to the OSPF database for a specific router.
<b>Step 14</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Changing LSA Group Pacing

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>router ospf process-id</b> <b>Example:</b>  Device(config)# router ospf 25	Enables OSPF routing, and enter router configuration mode.
<b>Step 3</b>	<b>timers lsa-group-pacing seconds</b> <b>Example:</b>  Device(config-router)# timers lsa-group-pacing 15	Changes the group pacing of LSAs.

	Command or Action	Purpose
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring a Loopback Interface

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface loopback 0</b> <b>Example:</b>  Device(config)# <b>interface loopback 0</b>	Creates a loopback interface, and enter interface configuration mode.
<b>Step 3</b>	<b>ip address address mask</b> <b>Example:</b>  Device(config-if)# <b>ip address 10.1.1.5 255.255.240.0</b>	Assign an IP address to this interface.
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 5</b>	<b>show ip interface</b> <b>Example:</b> Device# show ip interface	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Monitoring OSPF

You can display specific statistics such as the contents of IP routing tables, caches, and databases.

*Table 114: Show IP OSPF Statistics Commands*

<b>show ip ospf</b> [ <i>process-id</i> ]	Displays general information about OSPF routing processes.
<b>show ip ospf</b> [ <i>process-id</i> ] <b>database</b> [ <b>router</b> ] [ <i>link-state-id</i> ] <b>show ip ospf</b> [ <i>process-id</i> ] <b>database</b> [ <b>router</b> ] [ <b>self-originate</b> ] <b>show ip ospf</b> [ <i>process-id</i> ] <b>database</b> [ <b>router</b> ] [ <b>adv-router</b> [ <i>ip-address</i> ]] <b>show ip ospf</b> [ <i>process-id</i> ] <b>database</b> [ <b>network</b> ] [ <i>link-state-id</i> ] <b>show ip ospf</b> [ <i>process-id</i> ] <b>database</b> [ <b>summary</b> ] [ <i>link-state-id</i> ] <b>show ip ospf</b> [ <i>process-id</i> ] <b>database</b> [ <b>asbr-summary</b> ] [ <i>link-state-id</i> ] <b>show ip ospf</b> [ <i>process-id</i> ] <b>database</b> [ <b>external</b> ] [ <i>link-state-id</i> ] <b>show ip ospf</b> [ <i>process-id area-id</i> ] <b>database</b> [ <b>database-summary</b> ]	Displays lists of information related to the OSPF database.
<b>show ip ospf border-routes</b>	Displays the internal OSPF routing ABR and ASBR table entries.
<b>show ip ospf interface</b> [ <i>interface-name</i> ]	Displays OSPF-related interface information.



<b>show ip ospf neighbor</b> [ <i>interface-name</i> ] [ <i>neighbor-id</i> ] <b>detail</b>	Displays OSPF interface neighbor information.
<b>show ip ospf virtual-links</b>	Displays OSPF-related virtual links information.

## Configuration Examples for OSPF

### Example: Configuring Basic OSPF Parameters

This example shows how to configure an OSPF routing process and assign it a process number of 109:

```
Device(config)# router ospf 109
Device(config-router)# network 131.108.0.0 255.255.255.0 area 24
```

## Information About EIGRP

Enhanced IGRP (EIGRP) is a Cisco proprietary enhanced version of the IGRP. EIGRP uses the same distance vector algorithm and distance information as IGRP; however, the convergence properties and the operating efficiency of EIGRP are significantly improved.

The convergence technology employs an algorithm referred to as the Diffusing Update Algorithm (DUAL), which guarantees loop-free operation at every instant throughout a route computation and allows all devices involved in a topology change to synchronize at the same time. Routers that are not affected by topology changes are not involved in recomputations.

IP EIGRP provides increased network width. With RIP, the largest possible width of your network is 15 hops. Because the EIGRP metric is large enough to support thousands of hops, the only barrier to expanding the network is the transport-layer hop counter. EIGRP increments the transport control field only when an IP packet has traversed 15 routers and the next hop to the destination was learned through EIGRP. When a RIP route is used as the next hop to the destination, the transport control field is incremented as usual.

## EIGRP Features

EIGRP offers these features:

- Fast convergence.
- Incremental updates when the state of a destination changes, instead of sending the entire contents of the routing table, minimizing the bandwidth required for EIGRP packets.
- Less CPU usage because full update packets need not be processed each time they are received.
- Protocol-independent neighbor discovery mechanism to learn about neighboring routers.
- Variable-length subnet masks (VLSMs).
- Arbitrary route summarization.
- EIGRP scales to large networks.

## EIGRP Components

EIGRP has these four basic components:

- Neighbor discovery and recovery is the process that routers use to dynamically learn of other routers on their directly attached networks. Routers must also discover when their neighbors become unreachable or inoperative. Neighbor discovery and recovery is achieved with low overhead by periodically sending small hello packets. As long as hello packets are received, the Cisco IOS software can learn that a neighbor is alive and functioning. When this status is determined, the neighboring routers can exchange routing information.
- The reliable transport protocol is responsible for guaranteed, ordered delivery of EIGRP packets to all neighbors. It supports intermixed transmission of multicast and unicast packets. Some EIGRP packets must be sent reliably, and others need not be. For efficiency, reliability is provided only when necessary. For example, on a multiaccess network that has multicast capabilities (such as Ethernet), it is not necessary to send hellos reliably to all neighbors individually. Therefore, EIGRP sends a single multicast hello with an indication in the packet informing the receivers that the packet need not be acknowledged. Other types of packets (such as updates) require acknowledgment, which is shown in the packet. The reliable transport has a provision to send multicast packets quickly when there are unacknowledged packets pending. Doing so helps ensure that convergence time remains low in the presence of varying speed links.
- The DUAL finite state machine embodies the decision process for all route computations. It tracks all routes advertised by all neighbors. DUAL uses the distance information (known as a metric) to select efficient, loop-free paths. DUAL selects routes to be inserted into a routing table based on feasible successors. A successor is a neighboring router used for packet forwarding that has a least-cost path to a destination that is guaranteed not to be part of a routing loop. When there are no feasible successors, but there are neighbors advertising the destination, a recomputation must occur. This is the process whereby a new successor is determined. The amount of time it takes to recompute the route affects the convergence time. Recomputation is processor-intensive; it is advantageous to avoid recomputation if it is not necessary. When a topology change occurs, DUAL tests for feasible successors. If there are feasible successors, it uses any it finds to avoid unnecessary recomputation.
- The protocol-dependent modules are responsible for network layer protocol-specific tasks. An example is the IP EIGRP module, which is responsible for sending and receiving EIGRP packets that are encapsulated in IP. It is also responsible for parsing EIGRP packets and informing DUAL of the new information received. EIGRP asks DUAL to make routing decisions, but the results are stored in the IP routing table. EIGRP is also responsible for redistributing routes learned by other IP routing protocols.



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**Note** To enable EIGRP, the Device or stack master must be running the IP services feature set.

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## EIGRP Nonstop Forwarding

The Device stack supports two levels of EIGRP nonstop forwarding:

- EIGRP NSF Awareness
- EIGRP NSF Capability

## EIGRP NSF Awareness

The IP-services feature set supports EIGRP NSF Awareness for IPv4. When the neighboring router is NSF-capable, the Layer 3 Device continues to forward packets from the neighboring router during the interval between the primary Route Processor (RP) in a router failing and the backup RP taking over, or while the primary RP is manually reloaded for a nondisruptive software upgrade. This feature cannot be disabled.

## EIGRP NSF Capability

The IP services feature set supports EIGRP Cisco NSF routing to speed up convergence and to eliminate traffic loss after a stack master change.

The IP services feature set also supports EIGRP NSF-capable routing for IPv4 for better convergence and lower traffic loss following a stack master change. When an EIGRP NSF-capable stack master restarts or a new stack master starts up and NSF restarts, the Device has no neighbors, and the topology table is empty. The Device must bring up the interfaces, reacquire neighbors, and rebuild the topology and routing tables without interrupting the traffic directed toward the Device stack. EIGRP peer routers maintain the routes learned from the new stack master and continue forwarding traffic through the NSF restart process.

To prevent an adjacency reset by the neighbors, the new stack master uses a new Restart (RS) bit in the EIGRP packet header to show the restart. When the neighbor receives this, it synchronizes the stack in its peer list and maintains the adjacency with the stack. The neighbor then sends its topology table to the stack master with the RS bit set to show that it is NSF-aware and is aiding the new stack master.

If at least one of the stack peer neighbors is NSF-aware, the stack master receives updates and rebuilds its database. Each NSF-aware neighbor sends an end of table (EOT) marker in the last update packet to mark the end of the table content. The stack master recognizes the convergence when it receives the EOT marker, and it then begins sending updates. When the stack master has received all EOT markers from its neighbors or when the NSF converge timer expires, EIGRP notifies the routing information database (RIB) of convergence and floods its topology table to all NSF-aware peers.

## EIGRP Stub Routing

The EIGRP stub routing feature, available in all feature sets, reduces resource utilization by moving routed traffic closer to the end user.



**Note** The IP Base feature set contains EIGRP stub routing capability, which only advertises connected or summary routes from the routing tables to other device in the network. The device uses EIGRP stub routing at the access layer to eliminate the need for other types of routing advertisements. For enhanced capability and complete EIGRP routing, the device must be running the IP Base feature set. On a device running the IP base feature set, if you try to configure multi-VRF-CE and EIGRP stub routing at the same time, the configuration is not allowed. IPv6 EIGRP stub routing is not supported with the IP base feature set.

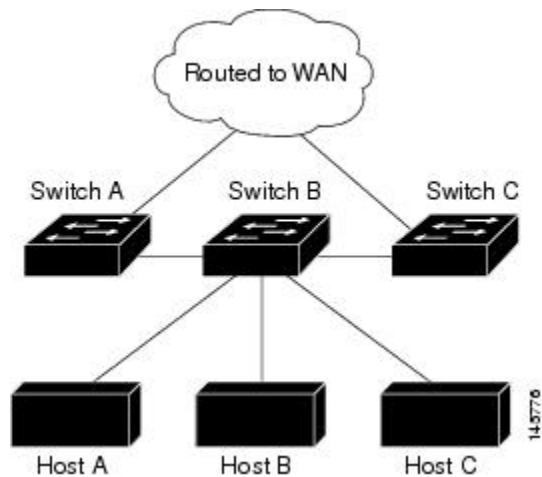
In a network using EIGRP stub routing, the only allowable route for IP traffic to the user is through a device that is configured with EIGRP stub routing. The device sends the routed traffic to interfaces that are configured as user interfaces or are connected to other devices.

When using EIGRP stub routing, you need to configure the distribution and remote routers to use EIGRP and to configure only the device as a stub. Only specified routes are propagated from the device. The device responds to all queries for summaries, connected routes, and routing updates.

Any neighbor that receives a packet informing it of the stub status does not query the stub router for any routes, and a router that has a stub peer does not query that peer. The stub router depends on the distribution router to send the proper updates to all peers.

In the figure given below, device B is configured as an EIGRP stub router. Devices A and C are connected to the rest of the WAN. Device B advertises connected, static, redistribution, and summary routes to Device A and C. Device B does not advertise any routes learned from Device A (and the reverse).

**Figure 100: EIGRP Stub Router Configuration**



## How to Configure EIGRP

To create an EIGRP routing process, you must enable EIGRP and associate networks. EIGRP sends updates to the interfaces in the specified networks. If you do not specify an interface network, it is not advertised in any EIGRP update.



**Note** If you have routers on your network that are configured for IGRP, and you want to change to EIGRP, you must designate transition routers that have both IGRP and EIGRP configured. In these cases, perform Steps 1 through 3 in the next section and also see the “Configuring Split Horizon” section. You must use the same AS number for routes to be automatically redistributed.

## Default EIGRP Configuration

**Table 115: Default EIGRP Configuration**

Feature	Default Setting
Auto summary	Disabled.
Default-information	Exterior routes are accepted and default information is passed between EIGRP processes when doing redistribution.

Feature	Default Setting
Default metric	<p>Only connected routes and interface static routes can be redistributed without a default metric. The metric includes:</p> <ul style="list-style-type: none"> <li>• Bandwidth: 0 or greater kb/s.</li> <li>• Delay (tens of microseconds): 0 or any positive number that is a multiple of 39.1 nanoseconds.</li> <li>• Reliability: any number between 0 and 255 (255 means 100 percent reliability).</li> <li>• Loading: effective bandwidth as a number between 0 and 255 (255 is 100 percent loading).</li> <li>• MTU: maximum transmission unit size of the route in bytes. 0 or any positive integer.</li> </ul>
Distance	<p>Internal distance: 90. External distance: 170.</p>
EIGRP log-neighbor changes	Disabled. No adjacency changes logged.
IP authentication key-chain	No authentication provided.
IP authentication mode	No authentication provided.
IP bandwidth-percent	50 percent.
IP hello interval	For low-speed nonbroadcast multiaccess (NBMA) networks: 60 seconds; all other networks: 5 seconds.
IP hold-time	For low-speed NBMA networks: 180 seconds; all other networks: 15 seconds.
IP split-horizon	Enabled.
IP summary address	No summary aggregate addresses are predefined.
Metric weights	tos: 0; k1 and k3: 1; k2, k4, and k5: 0
Network	None specified.
Nonstop Forwarding (NSF) Awareness	Enabled for IPv4 on switches running the IP services feature set. Allows Layer 3 switches to continue forwarding packets from a neighboring NSF-capable router during hardware or software changes.
NSF capability	<p>Disabled.</p> <p><b>Note</b> The Device supports EIGRP NSF-capable routing for IPv4.</p>

Feature	Default Setting
Offset-list	Disabled.
Router EIGRP	Disabled.
Set metric	No metric set in the route map.
Traffic-share	Distributed proportionately to the ratios of the metrics.
Variance	1 (equal-cost load-balancing).

## Configuring Basic EIGRP Parameters

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>router eigrp</b> autonomous-system <b>Example:</b>  Device(config)# <b>router eigrp</b> 10	Enables an EIGRP routing process, and enter router configuration mode. The AS number identifies the routes to other EIGRP routers and is used to tag routing information.
<b>Step 3</b>	<b>nsf</b> <b>Example:</b>  Device(config)# <b>nsf</b>	(Optional) Enables EIGRP NSF. Enter this command on the stack master and on all of its peers.
<b>Step 4</b>	<b>network</b> network-number <b>Example:</b>  Device(config)# <b>network</b> 192.168.0.0	Associate networks with an EIGRP routing process. EIGRP sends updates to the interfaces in the specified networks.
<b>Step 5</b>	<b>eigrp log-neighbor-changes</b> <b>Example:</b>  Device(config)# <b>eigrp</b> <b>log-neighbor-changes</b>	(Optional) Enables logging of EIGRP neighbor changes to monitor routing system stability.
<b>Step 6</b>	<b>metric weights</b> tos k1 k2 k3 k4 k5 <b>Example:</b>  Device(config)# <b>metric weights</b> 0 2 0 2 0 0	(Optional) Adjust the EIGRP metric. Although the defaults have been carefully set to provide excellent operation in most networks, you can adjust them.

	Command or Action	Purpose
		<b>Caution</b> Setting metrics is complex and is not recommended without guidance from an experienced network designer.
<b>Step 7</b>	<b>offset-list</b> [ <i>access-list number   name</i> ] { <b>in</b>   <b>out</b> } <i>offset [type number]</i> <b>Example:</b> Device(config)# <b>offset-list 21 out 10</b>	(Optional) Applies an offset list to routing metrics to increase incoming and outgoing metrics to routes learned through EIGRP. You can limit the offset list with an access list or an interface.
<b>Step 8</b>	<b>auto-summary</b> <b>Example:</b> Device(config)# <b>auto-summary</b>	(Optional) Enables automatic summarization of subnet routes into network-level routes.
<b>Step 9</b>	<b>ip summary-address eigrp</b> <i>autonomous-system-number address mask</i> <b>Example:</b> Device(config)# <b>ip summary-address eigrp 1 192.168.0.0 255.255.0.0</b>	(Optional) Configures a summary aggregate.
<b>Step 10</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 11</b>	<b>show ip protocols</b> <b>Example:</b> Device# <b>show ip protocols</b>	Verifies your entries. For NSF awareness, the output shows: *** IP Routing is NSF aware *** EIGRP NSF enabled
<b>Step 12</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring EIGRP Interfaces

Other optional EIGRP parameters can be configured on an interface basis.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device (config)# interface gigabitethernet 1/0/1	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
<b>Step 3</b>	<b>ip bandwidth-percent eigrp <i>percent</i></b> <b>Example:</b>  Device (config-if)# ip bandwidth-percent eigrp 60	(Optional) Configures the percentage of bandwidth that can be used by EIGRP on an interface. The default is 50 percent.
<b>Step 4</b>	<b>ip summary-address eigrp <i>autonomous-system-number address mask</i></b> <b>Example:</b>  Device (config-if)# ip summary-address eigrp 109 192.161.0.0 255.255.0.0	(Optional) Configures a summary aggregate address for a specified interface (not usually necessary if auto-summary is enabled).
<b>Step 5</b>	<b>ip hello-interval eigrp <i>autonomous-system-number seconds</i></b> <b>Example:</b>  Device (config-if)# ip hello-interval eigrp 109 10	(Optional) Change the hello time interval for an EIGRP routing process. The range is 1 to 65535 seconds. The default is 60 seconds for low-speed NBMA networks and 5 seconds for all other networks.
<b>Step 6</b>	<b>ip hold-time eigrp <i>autonomous-system-number seconds</i></b> <b>Example:</b>  Device (config-if)# ip hold-time eigrp 109 40	(Optional) Change the hold time interval for an EIGRP routing process. The range is 1 to 65535 seconds. The default is 180 seconds for low-speed NBMA networks and 15 seconds for all other networks.  <b>Caution</b> Do not adjust the hold time without consulting Cisco technical support.
<b>Step 7</b>	<b>no ip split-horizon eigrp <i>autonomous-system-number</i></b> <b>Example:</b>  Device (config-if)# no ip split-horizon eigrp 109	(Optional) Disables split horizon to allow route information to be advertised by a router out any interface from which that information originated.



	Command or Action	Purpose
<b>Step 8</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 9</b>	<b>show ip eigrp interface</b> <b>Example:</b>  Device# show ip eigrp interface	Displays which interfaces EIGRP is active on and information about EIGRP relating to those interfaces.
<b>Step 10</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Configuring EIGRP Route Authentication

EIGRP route authentication provides MD5 authentication of routing updates from the EIGRP routing protocol to prevent the introduction of unauthorized or false routing messages from unapproved sources.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface interface-id</b> <b>Example:</b>  Device(config)# interface gigabitethernet 1/0/1	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
<b>Step 3</b>	<b>ip authentication mode eigrp autonomous-system md5</b> <b>Example:</b>  Device(config-if)# ip authentication mode eigrp 104 md5	Enables MD5 authentication in IP EIGRP packets.
<b>Step 4</b>	<b>ip authentication key-chain eigrp autonomous-system key-chain</b>	Enables authentication of IP EIGRP packets.

	Command or Action	Purpose
	<b>Example:</b> <pre>Device(config-if)# ip authentication key-chain eigrp 105 chain1</pre>	
<b>Step 5</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-if)# exit</pre>	Returns to global configuration mode.
<b>Step 6</b>	<b>key chain <i>name-of-chain</i></b> <b>Example:</b> <pre>Device(config)# key chain chain1</pre>	Identify a key chain and enter key-chain configuration mode. Match the name configured in Step 4.
<b>Step 7</b>	<b>key <i>number</i></b> <b>Example:</b> <pre>Device(config-keychain)# key 1</pre>	In key-chain configuration mode, identify the key number.
<b>Step 8</b>	<b>key-string <i>text</i></b> <b>Example:</b> <pre>Device(config-keychain-key)# key-string key1</pre>	In key-chain key configuration mode, identify the key string.
<b>Step 9</b>	<b>accept-lifetime <i>start-time</i> {infinite   <i>end-time</i>   <i>duration seconds</i>}</b> <b>Example:</b> <pre>Device(config-keychain-key)# accept-lifetime 13:30:00 Jan 25 2011 duration 7200</pre>	(Optional) Specifies the time period during which the key can be received.  The <i>start-time</i> and <i>end-time</i> syntax can be either <i>hh:mm:ss Month date year</i> or <i>hh:mm:ss date Month year</i> . The default is forever with the default <i>start-time</i> and the earliest acceptable date as January 1, 1993. The default <i>end-time</i> and <b>duration</b> is <b>infinite</b> .
<b>Step 10</b>	<b>send-lifetime <i>start-time</i> {infinite   <i>end-time</i>   <i>duration seconds</i>}</b> <b>Example:</b> <pre>Device(config-keychain-key)# send-lifetime 14:00:00 Jan 25 2011 duration 3600</pre>	(Optional) Specifies the time period during which the key can be sent.  The <i>start-time</i> and <i>end-time</i> syntax can be either <i>hh:mm:ss Month date year</i> or <i>hh:mm:ss date Month year</i> . The default is forever with the default <i>start-time</i> and the earliest acceptable date as January 1, 1993. The default <i>end-time</i> and <b>duration</b> is <b>infinite</b> .
<b>Step 11</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 12</b>	<b>show key chain</b> <b>Example:</b> Device# show key chain	Displays authentication key information.
<b>Step 13</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Monitoring and Maintaining EIGRP

You can delete neighbors from the neighbor table. You can also display various EIGRP routing statistics. The table given below lists the privileged EXEC commands for deleting neighbors and displaying statistics.

**Table 116: IP EIGRP Clear and Show Commands**

<b>clear ip eigrp neighbors</b> [ <i>if-address</i>   <i>interface</i> ]	Deletes neighbors from the neighbor table.
<b>show ip eigrp interface</b> [ <i>interface</i> ] [ <i>as number</i> ]	Displays information about interfaces configured for EIGRP.
<b>show ip eigrp neighbors</b> [ <i>type-number</i> ]	Displays EIGRP discovered neighbors.
<b>show ip eigrp topology</b> [ <i>autonomous-system-number</i> ]   [[ <i>ip-address</i> ] <i>mask</i> ]]	Displays the EIGRP topology table for a given process.
<b>show ip eigrp traffic</b> [ <i>autonomous-system-number</i> ]	Displays the number of packets sent and received for all or a specified EIGRP process.

## Information About BGP

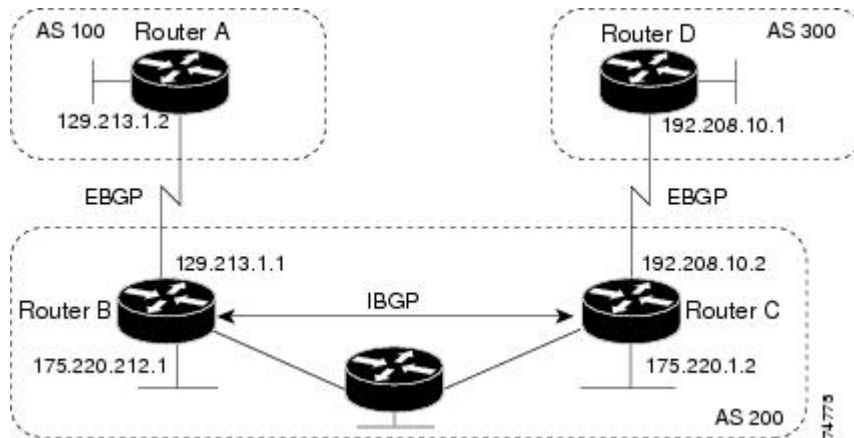
The Border Gateway Protocol (BGP) is an exterior gateway protocol used to set up an interdomain routing system that guarantees the loop-free exchange of routing information between autonomous systems. Autonomous systems are made up of routers that operate under the same administration and that run Interior Gateway Protocols (IGPs), such as RIP or OSPF, within their boundaries and that interconnect by using an Exterior Gateway Protocol (EGP). BGP Version 4 is the standard EGP for interdomain routing in the Internet. The protocol is defined in RFCs 1163, 1267, and 1771.

## BGP Network Topology

Routers that belong to the same autonomous system (AS) and that exchange BGP updates run internal BGP (IBGP), and routers that belong to different autonomous systems and that exchange BGP updates run external

BGP (EBGP). Most configuration commands are the same for configuring EBGP and IBGP. The difference is that the routing updates are exchanged either between autonomous systems (EBGP) or within an AS (IBGP). The figure given below shows a network that is running both EBGP and IBGP.

**Figure 101: EBGP, IBGP, and Multiple Autonomous Systems**



Before exchanging information with an external AS, BGP ensures that networks within the AS can be reached by defining internal BGP peering among routers within the AS and by redistributing BGP routing information to IGPs that run within the AS, such as IGRP and OSPF.

Routers that run a BGP routing process are often referred to as BGP speakers. BGP uses the Transmission Control Protocol (TCP) as its transport protocol (specifically port 179). Two BGP speakers that have a TCP connection to each other for exchanging routing information are known as peers or neighbors. In the above figure, Routers A and B are BGP peers, as are Routers B and C and Routers C and D. The routing information is a series of AS numbers that describe the full path to the destination network. BGP uses this information to construct a loop-free map of autonomous systems.

The network has these characteristics:

- Routers A and B are running EBGP, and Routers B and C are running IBGP. Note that the EBGP peers are directly connected and that the IBGP peers are not. As long as there is an IGP running that allows the two neighbors to reach one another, IBGP peers do not have to be directly connected.
- All BGP speakers within an AS must establish a peer relationship with each other. That is, the BGP speakers within an AS must be fully meshed logically. BGP4 provides two techniques that reduce the requirement for a logical full mesh: confederations and route reflectors.
- AS 200 is a transit AS for AS 100 and AS 300—that is, AS 200 is used to transfer packets between AS 100 and AS 300.

BGP peers initially exchange their full BGP routing tables and then send only incremental updates. BGP peers also exchange keepalive messages (to ensure that the connection is up) and notification messages (in response to errors or special conditions).

In BGP, each route consists of a network number, a list of autonomous systems that information has passed through (the autonomous system path), and a list of other path attributes. The primary function of a BGP system is to exchange network reachability information, including information about the list of AS paths, with other BGP systems. This information can be used to determine AS connectivity, to prune routing loops, and to enforce AS-level policy decisions.

A router or Device running Cisco IOS does not select or use an IBGP route unless it has a route available to the next-hop router and it has received synchronization from an IGP (unless IGP synchronization is disabled). When multiple routes are available, BGP bases its path selection on attribute values. See the “Configuring BGP Decision Attributes” section for information about BGP attributes.

BGP Version 4 supports classless interdomain routing (CIDR) so you can reduce the size of your routing tables by creating aggregate routes, resulting in supernets. CIDR eliminates the concept of network classes within BGP and supports the advertising of IP prefixes.

## Nonstop Forwarding Awareness

The BGP NSF Awareness feature is supported for IPv4 in the IP services feature set. . To enable this feature with BGP routing, you need to enable Graceful Restart. When the neighboring router is NSF-capable, and this feature is enabled, the Layer 3 Device continues to forward packets from the neighboring router during the interval between the primary Route Processor (RP) in a router failing and the backup RP taking over, or while the primary RP is manually reloaded for a nondisruptive software upgrade.

## Information About BGP Routing

To enable BGP routing, you establish a BGP routing process and define the local network. Because BGP must completely recognize the relationships with its neighbors, you must also specify a BGP neighbor.

BGP supports two kinds of neighbors: internal and external. Internal neighbors are in the same AS; external neighbors are in different autonomous systems. External neighbors are usually adjacent to each other and share a subnet, but internal neighbors can be anywhere in the same AS.

The switch supports the use of private AS numbers, usually assigned by service providers and given to systems whose routes are not advertised to external neighbors. The private AS numbers are from 64512 to 65535. You can configure external neighbors to remove private AS numbers from the AS path by using the **neighbor remove-private-as** router configuration command. Then when an update is passed to an external neighbor, if the AS path includes private AS numbers, these numbers are dropped.

If your AS will be passing traffic through it from another AS to a third AS, it is important to be consistent about the routes it advertises. If BGP advertised a route before all routers in the network had learned about the route through the IGP, the AS might receive traffic that some routers could not yet route. To prevent this from happening, BGP must wait until the IGP has propagated information across the AS so that BGP is synchronized with the IGP. Synchronization is enabled by default. If your AS does not pass traffic from one AS to another AS, or if all routers in your autonomous systems are running BGP, you can disable synchronization, which allows your network to carry fewer routes in the IGP and allows BGP to converge more quickly.

## Routing Policy Changes

Routing policies for a peer include all the configurations that might affect inbound or outbound routing table updates. When you have defined two routers as BGP neighbors, they form a BGP connection and exchange routing information. If you later change a BGP filter, weight, distance, version, or timer, or make a similar configuration change, you must reset the BGP sessions so that the configuration changes take effect.

There are two types of reset, hard reset and soft reset. Cisco IOS Releases 12.1 and later support a soft reset without any prior configuration. To use a soft reset without preconfiguration, both BGP peers must support the soft route refresh capability, which is advertised in the OPEN message sent when the peers establish a

TCP session. A soft reset allows the dynamic exchange of route refresh requests and routing information between BGP routers and the subsequent re-advertisement of the respective outbound routing table.

- When soft reset generates inbound updates from a neighbor, it is called dynamic inbound soft reset.
- When soft reset sends a set of updates to a neighbor, it is called outbound soft reset.

A soft inbound reset causes the new inbound policy to take effect. A soft outbound reset causes the new local outbound policy to take effect without resetting the BGP session. As a new set of updates is sent during outbound policy reset, a new inbound policy can also take effect.

The table given below lists the advantages and disadvantages hard reset and soft reset.

**Table 117: Advantages and Disadvantages of Hard and Soft Resets**

Type of Reset	Advantages	Disadvantages
Hard reset	No memory overhead	The prefixes in the BGP, IP, and FIB tables provided by the neighbor are lost. Not recommended.
Outbound soft reset	No configuration, no storing of routing table updates	Does not reset inbound routing table updates.
Dynamic inbound soft reset	Does not clear the BGP session and cache  Does not require storing of routing table updates and has no memory overhead	Both BGP routers must support the route refresh capability (in Cisco IOS Release 12.1 and later).

## BGP Decision Attributes

When a BGP speaker receives updates from multiple autonomous systems that describe different paths to the same destination, it must choose the single best path for reaching that destination. When chosen, the selected path is entered into the BGP routing table and propagated to its neighbors. The decision is based on the value of attributes that the update contains and other BGP-configurable factors.

When a BGP peer learns two EBGP paths for a prefix from a neighboring AS, it chooses the best path and inserts that path in the IP routing table. If BGP multipath support is enabled and the EBGP paths are learned from the same neighboring autonomous systems, instead of a single best path, multiple paths are installed in the IP routing table. Then, during packet switching, per-packet or per-destination load-balancing is performed among the multiple paths. The **maximum-paths** router configuration command controls the number of paths allowed.

These factors summarize the order in which BGP evaluates the attributes for choosing the best path:

1. If the path specifies a next hop that is inaccessible, drop the update. The BGP next-hop attribute, automatically determined by the software, is the IP address of the next hop that is going to be used to reach a destination. For EBGP, this is usually the IP address of the neighbor specified by the **neighbor remote-as router** configuration command. You can disable next-hop processing by using route maps or the **neighbor next-hop-self** router configuration command.
2. Prefer the path with the largest weight (a Cisco proprietary parameter). The weight attribute is local to the router and not propagated in routing updates. By default, the weight attribute is 32768 for paths that

the router originates and zero for other paths. Routes with the largest weight are preferred. You can use access lists, route maps, or the **neighbor weight** router configuration command to set weights.

3. Prefer the route with the highest local preference. Local preference is part of the routing update and exchanged among routers in the same AS. The default value of the local preference attribute is 100. You can set local preference by using the **bgp default local-preference** router configuration command or by using a route map.
4. Prefer the route that was originated by BGP running on the local router.
5. Prefer the route with the shortest AS path.
6. Prefer the route with the lowest origin type. An interior route or IGP is lower than a route learned by EGP, and an EGP-learned route is lower than one of unknown origin or learned in another way.
7. Prefer the route with the lowest multi-exit discriminator (MED) metric attribute if the neighboring AS is the same for all routes considered. You can configure the MED by using route maps or by using the **default-metric** router configuration command. When an update is sent to an IBGP peer, the MED is included.
8. Prefer the external (EBGP) path over the internal (IBGP) path.
9. Prefer the route that can be reached through the closest IGP neighbor (the lowest IGP metric). This means that the router will prefer the shortest internal path within the AS to reach the destination (the shortest path to the BGP next-hop).
10. If the following conditions are all true, insert the route for this path into the IP routing table:
  - Both the best route and this route are external.
  - Both the best route and this route are from the same neighboring autonomous system.
  - Maximum-paths is enabled.
11. If multipath is not enabled, prefer the route with the lowest IP address value for the BGP router ID. The router ID is usually the highest IP address on the router or the loopback (virtual) address, but might be implementation-specific.

## Route Maps

Within BGP, route maps can be used to control and to modify routing information and to define the conditions by which routes are redistributed between routing domains. Each route map has a name that identifies the route map (*map tag*) and an optional sequence number.

## BGP Filtering

You can filter BGP advertisements by using AS-path filters, such as the **as-path access-list** global configuration command and the **neighbor filter-list** router configuration command. You can also use access lists with the **neighbor distribute-list** router configuration command. Distribute-list filters are applied to network numbers. See the “Controlling Advertising and Processing in Routing Updates” section for information about the **distribute-list** command.

You can use route maps on a per-neighbor basis to filter updates and to modify various attributes. A route map can be applied to either inbound or outbound updates. Only the routes that pass the route map are sent or accepted in updates. On both inbound and outbound updates, matching is supported based on AS path,

community, and network numbers. Autonomous system path matching requires the **match as-path access-list** route-map command, community based matching requires the **match community-list** route-map command, and network-based matching requires the **ip access-list** global configuration command.

## Prefix List for BGP Filtering

You can use prefix lists as an alternative to access lists in many BGP route filtering commands, including the **neighbor distribute-list** router configuration command. The advantages of using prefix lists include performance improvements in loading and lookup of large lists, incremental update support, easier CLI configuration, and greater flexibility.

Filtering by a prefix list involves matching the prefixes of routes with those listed in the prefix list, as when matching access lists. When there is a match, the route is used. Whether a prefix is permitted or denied is based upon these rules:

- An empty prefix list permits all prefixes.
- An implicit deny is assumed if a given prefix does not match any entries in a prefix list.
- When multiple entries of a prefix list match a given prefix, the sequence number of a prefix list entry identifies the entry with the lowest sequence number.

By default, sequence numbers are generated automatically and incremented in units of five. If you disable the automatic generation of sequence numbers, you must specify the sequence number for each entry. You can specify sequence values in any increment. If you specify increments of one, you cannot insert additional entries into the list; if you choose very large increments, you might run out of values.

## BGP Community Filtering

One way that BGP controls the distribution of routing information based on the value of the COMMUNITIES attribute. The attribute is a way to group destinations into communities and to apply routing decisions based on the communities. This method simplifies configuration of a BGP speaker to control distribution of routing information.

A community is a group of destinations that share some common attribute. Each destination can belong to multiple communities. AS administrators can define to which communities a destination belongs. By default, all destinations belong to the general Internet community. The community is identified by the COMMUNITIES attribute, an optional, transitive, global attribute in the numerical range from 1 to 4294967200. These are some predefined, well-known communities:

- **internet**—Advertise this route to the Internet community. All routers belong to it.
- **no-export**—Do not advertise this route to EBGp peers.
- **no-advertise**—Do not advertise this route to any peer (internal or external).
- **local-as**—Do not advertise this route to peers outside the local autonomous system.

Based on the community, you can control which routing information to accept, prefer, or distribute to other neighbors. A BGP speaker can set, append, or modify the community of a route when learning, advertising, or redistributing routes. When routes are aggregated, the resulting aggregate has a COMMUNITIES attribute that contains all communities from all the initial routes.



You can use community lists to create groups of communities to use in a match clause of a route map. As with an access list, a series of community lists can be created. Statements are checked until a match is found. As soon as one statement is satisfied, the test is concluded.

## BGP Neighbors and Peer Groups

Often many BGP neighbors are configured with the same update policies (that is, the same outbound route maps, distribute lists, filter lists, update source, and so on). Neighbors with the same update policies can be grouped into peer groups to simplify configuration and to make updating more efficient. When you have configured many peers, we recommend this approach.

To configure a BGP peer group, you create the peer group, assign options to the peer group, and add neighbors as peer group members. You configure the peer group by using the **neighbor** router configuration commands. By default, peer group members inherit all the configuration options of the peer group, including the remote-as (if configured), version, update-source, out-route-map, out-filter-list, out-dist-list, minimum-advertisement-interval, and next-hop-self. All peer group members also inherit changes made to the peer group. Members can also be configured to override the options that do not affect outbound updates.

## Aggregate Routes

Classless interdomain routing (CIDR) enables you to create aggregate routes (or supernets) to minimize the size of routing tables. You can configure aggregate routes in BGP either by redistributing an aggregate route into BGP or by creating an aggregate entry in the BGP routing table. An aggregate address is added to the BGP table when there is at least one more specific entry in the BGP table.

## Routing Domain Confederations

One way to reduce the IBGP mesh is to divide an autonomous system into multiple subautonomous systems and to group them into a single confederation that appears as a single autonomous system. Each autonomous system is fully meshed within itself and has a few connections to other autonomous systems in the same confederation. Even though the peers in different autonomous systems have EBGP sessions, they exchange routing information as if they were IBGP peers. Specifically, the next hop, MED, and local preference information is preserved. You can then use a single IGP for all of the autonomous systems.

## BGP Route Reflectors

BGP requires that all of the IBGP speakers be fully meshed. When a router receives a route from an external neighbor, it must advertise it to all internal neighbors. To prevent a routing information loop, all IBGP speakers must be connected. The internal neighbors do not send routes learned from internal neighbors to other internal neighbors.

With route reflectors, all IBGP speakers need not be fully meshed because another method is used to pass learned routes to neighbors. When you configure an internal BGP peer to be a route reflector, it is responsible for passing IBGP learned routes to a set of IBGP neighbors. The internal peers of the route reflector are divided into two groups: client peers and nonclient peers (all the other routers in the autonomous system). A route reflector reflects routes between these two groups. The route reflector and its client peers form a cluster. The nonclient peers must be fully meshed with each other, but the client peers need not be fully meshed. The clients in the cluster do not communicate with IBGP speakers outside their cluster.

When the route reflector receives an advertised route, it takes one of these actions, depending on the neighbor:

- A route from an external BGP speaker is advertised to all clients and nonclient peers.
- A route from a nonclient peer is advertised to all clients.
- A route from a client is advertised to all clients and nonclient peers. Hence, the clients need not be fully meshed.

Usually a cluster of clients have a single route reflector, and the cluster is identified by the route reflector router ID. To increase redundancy and to avoid a single point of failure, a cluster might have more than one route reflector. In this case, all route reflectors in the cluster must be configured with the same 4-byte cluster ID so that a route reflector can recognize updates from route reflectors in the same cluster. All the route reflectors serving a cluster should be fully meshed and should have identical sets of client and nonclient peers.

## Route Dampening

Route flap dampening is a BGP feature designed to minimize the propagation of flapping routes across an internetwork. A route is considered to be flapping when it is repeatedly available, then unavailable, then available, then unavailable, and so on. When route dampening is enabled, a numeric penalty value is assigned to a route when it flaps. When a route's accumulated penalties reach a configurable limit, BGP suppresses advertisements of the route, even if the route is running. The reuse limit is a configurable value that is compared with the penalty. If the penalty is less than the reuse limit, a suppressed route that is up is advertised again.

Dampening is not applied to routes that are learned by IBGP. This policy prevents the IBGP peers from having a higher penalty for routes external to the AS.

## How to Configure BGP

### Default BGP Configuration

The table given below shows the basic default BGP configuration.

**Table 118: Default BGP Configuration**

Feature	Default Setting
Aggregate address	Disabled: None defined.
AS path access list	None defined.
Auto summary	Disabled.
Best path	<ul style="list-style-type: none"> <li>• The router considers <i>as-path</i> in choosing a route and does not compare similar routes from external BGP peers.</li> <li>• Compare router ID: Disabled.</li> </ul>

Feature	Default Setting
BGP community list	<ul style="list-style-type: none"> <li>• Number: None defined. When you permit a value for the community number, the list defaults to an implicit deny for everything else that has not been permitted.</li> <li>• Format: Cisco default format (32-bit number).</li> </ul>
BGP confederation identifier/peers	<ul style="list-style-type: none"> <li>• Identifier: None configured.</li> <li>• Peers: None identified.</li> </ul>
BGP Fast external fallover	Enabled.
BGP local preference	100. The range is 0 to 4294967295 with the higher value preferred.
BGP network	None specified; no backdoor route advertised.
BGP route dampening	<p>Disabled by default. When enabled:</p> <ul style="list-style-type: none"> <li>• Half-life is 15 minutes.</li> <li>• Re-use is 750 (10-second increments).</li> <li>• Suppress is 2000 (10-second increments).</li> <li>• Max-suppress-time is 4 times half-life; 60 minutes.</li> </ul>
BGP router ID	The IP address of a loopback interface if one is configured or the highest IP address configured for a physical interface on the router.
Default information originate (protocol or network redistribution)	Disabled.
Default metric	Built-in, automatic metric translations.
Distance	<ul style="list-style-type: none"> <li>• External route administrative distance: 20 (acceptable values are from 1 to 255).</li> <li>• Internal route administrative distance: 200 (acceptable values are from 1 to 255).</li> <li>• Local route administrative distance: 200 (acceptable values are from 1 to 255).</li> </ul>
Distribute list	<ul style="list-style-type: none"> <li>• In (filter networks received in updates): Disabled.</li> <li>• Out (suppress networks from being advertised in updates): Disabled.</li> </ul>

Feature	Default Setting
Internal route redistribution	Disabled.
IP prefix list	None defined.
Multi exit discriminator (MED)	<ul style="list-style-type: none"><li>• Always compare: Disabled. Does not compare MEDs for paths from neighbors in different autonomous systems.</li><li>• Best path compare: Disabled.</li><li>• MED missing as worst path: Disabled.</li><li>• Deterministic MED comparison is disabled.</li></ul>

Feature	Default Setting
Neighbor	<ul style="list-style-type: none"> <li>• Advertisement interval: 30 seconds for external peers; 5 seconds for internal peers.</li> <li>• Change logging: Enabled.</li> <li>• Conditional advertisement: Disabled.</li> <li>• Default originate: No default route is sent to the neighbor.</li> <li>• Description: None.</li> <li>• Distribute list: None defined.</li> <li>• External BGP multihop: Only directly connected neighbors are allowed.</li> <li>• Filter list: None used.</li> <li>• Maximum number of prefixes received: No limit.</li> <li>• Next hop (router as next hop for BGP neighbor): Disabled.</li> <li>• Password: Disabled.</li> <li>• Peer group: None defined; no members assigned.</li> <li>• Prefix list: None specified.</li> <li>• Remote AS (add entry to neighbor BGP table): No peers defined.</li> <li>• Private AS number removal: Disabled.</li> <li>• Route maps: None applied to a peer.</li> <li>• Send community attributes: None sent to neighbors.</li> <li>• Shutdown or soft reconfiguration: Not enabled.</li> <li>• Timers: keepalive: 60 seconds; holdtime: 180 seconds.</li> <li>• Update source: Best local address.</li> <li>• Version: BGP Version 4.</li> <li>• Weight: Routes learned through BGP peer: 0; routes sourced by the local router: 32768.</li> </ul>
NSF <sup>6</sup> Awareness	Disabled <sup>7</sup> . If enabled, allows Layer 3 switches to continue forwarding packets from a neighboring NSF-capable router during hardware or software changes.

Feature	Default Setting
Route reflector	None configured.
Synchronization (BGP and IGP)	Disabled.
Table map update	Disabled.
Timers	Keepalive: 60 seconds; holdtime: 180 seconds.

<sup>6</sup> Nonstop Forwarding

<sup>7</sup> NSF Awareness can be enabled for IPv4 on switches with the IP services feature set license by enabling Graceful Restart.

## Enabling BGP Routing

### Before you begin



**Note** To enable BGP, the switch or stack master must be running the IP services feature set.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ip routing</b> <b>Example:</b>  Device(config)# <code>ip routing</code>	Enables IP routing.
<b>Step 3</b>	<b>router bgp</b> <i>autonomous-system</i> <b>Example:</b>  Device(config)# <code>router bgp 45000</code>	Enables a BGP routing process, assign it an AS number, and enter router configuration mode. The AS number can be from 1 to 65535, with 64512 to 65535 designated as private autonomous numbers.
<b>Step 4</b>	<b>network</b> <i>network-number</i> [ <b>mask</b> <i>network-mask</i> ] [ <b>route-map</b> <i>route-map-name</i> ] <b>Example:</b>  Device(config)# <code>network 10.108.0.0</code>	Configures a network as local to this AS, and enter it in the BGP table.

	Command or Action	Purpose
<b>Step 5</b>	<b>neighbor</b> <i>{ip-address   peer-group-name}</i> <b>remote-as</b> <i>number</i> <b>Example:</b> <pre>Device(config)# neighbor 10.108.1.2 remote-as 65200</pre>	<p>Adds an entry to the BGP neighbor table specifying that the neighbor identified by the IP address belongs to the specified AS.</p> <p>For EBGP, neighbors are usually directly connected, and the IP address is the address of the interface at the other end of the connection.</p> <p>For IBGP, the IP address can be the address of any of the router interfaces.</p>
<b>Step 6</b>	<b>neighbor</b> <i>{ip-address   peer-group-name}</i> <b>remove-private-as</b> <b>Example:</b> <pre>Device(config)# neighbor 172.16.2.33 remove-private-as</pre>	(Optional) Removes private AS numbers from the AS-path in outbound routing updates.
<b>Step 7</b>	<b>synchronization</b> <b>Example:</b> <pre>Device(config)# synchronization</pre>	(Optional) Enables synchronization between BGP and an IGP.
<b>Step 8</b>	<b>auto-summary</b> <b>Example:</b> <pre>Device(config)# auto-summary</pre>	(Optional) Enables automatic network summarization. When a subnet is redistributed from an IGP into BGP, only the network route is inserted into the BGP table.
<b>Step 9</b>	<b>bgp graceful-restart</b> <b>Example:</b> <pre>Device(config)# bgp graceful-start</pre>	(Optional) Enables NSF awareness on switch. By default, NSF awareness is disabled.
<b>Step 10</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 11</b>	<b>show ip bgp network</b> <i>network-number</i> <b>Example:</b> <pre>Device# show ip bgp network 10.108.0.0</pre>	Verifies the configuration.
<b>Step 12</b>	<b>show ip bgp neighbor</b> <b>Example:</b> <pre>Device# show ip bgp neighbor</pre>	<p>Verifies that NSF awareness (Graceful Restart) is enabled on the neighbor.</p> <p>If NSF awareness is enabled on the switch and the neighbor, this message appears:</p>

	Command or Action	Purpose
		<p><i>Graceful Restart Capability: advertised and received</i></p> <p>If NSF awareness is enabled on the switch, but not on the neighbor, this message appears:</p> <p><i>Graceful Restart Capability: advertised</i></p>
<b>Step 13</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Managing Routing Policy Changes

To learn if a BGP peer supports the route refresh capability and to reset the BGP session:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>show ip bgp neighbors</b></p> <p><b>Example:</b></p> <pre>Device# show ip bgp neighbors</pre>	<p>Displays whether a neighbor supports the route refresh capability. When supported, this message appears for the router:</p> <p><i>Received route refresh capability from peer.</i></p>
<b>Step 2</b>	<p><b>clear ip bgp {*   address   peer-group-name}</b></p> <p><b>Example:</b></p> <pre>Device# clear ip bgp *</pre>	<p>Resets the routing table on the specified connection.</p> <ul style="list-style-type: none"> <li>• Enter an asterisk (*) to specify that all connections be reset.</li> <li>• Enter an IP address to specify the connection to be reset.</li> <li>• Enter a peer group name to reset the peer group.</li> </ul>
<b>Step 3</b>	<p><b>clear ip bgp {*   address   peer-group-name} soft out</b></p> <p><b>Example:</b></p> <pre>Device# clear ip bgp * soft out</pre>	<p>(Optional) Performs an outbound soft reset to reset the inbound routing table on the specified connection. Use this command if route refresh is supported.</p> <ul style="list-style-type: none"> <li>• Enter an asterisk (*) to specify that all connections be reset.</li> <li>• Enter an IP address to specify the connection to be reset.</li> </ul>



	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>Enter a peer group name to reset the peer group.</li> </ul>
<b>Step 4</b>	<b>show ip bgp</b> <b>Example:</b> Device# show ip bgp	Verifies the reset by checking information about the routing table and about BGP neighbors.
<b>Step 5</b>	<b>show ip bgp neighbors</b> <b>Example:</b> Device# show ip bgp neighbors	Verifies the reset by checking information about the routing table and about BGP neighbors.

## Configuring BGP Decision Attributes

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>router bgp <i>autonomous-system</i></b> <b>Example:</b> Device(config)# router bgp 4500	Enables a BGP routing process, assign it an AS number, and enter router configuration mode.
<b>Step 3</b>	<b>bgp best-path as-path ignore</b> <b>Example:</b> Device(config-router)# bgp bestpath as-path ignore	(Optional) Configures the router to ignore AS path length in selecting a route.
<b>Step 4</b>	<b>neighbor {<i>ip-address</i>   <i>peer-group-name</i>}</b> <b>next-hop-self</b> <b>Example:</b> Device(config-router)# neighbor 10.108.1.1 next-hop-self	(Optional) Disables next-hop processing on BGP updates to a neighbor by entering a specific IP address to be used instead of the next-hop address.
<b>Step 5</b>	<b>neighbor {<i>ip-address</i>   <i>peer-group-name</i>}</b> <b>weight <i>weight</i></b> <b>Example:</b>	(Optional) Assign a weight to a neighbor connection. Acceptable values are from 0 to 65535; the largest weight is the preferred route. Routes learned through another BGP peer have

	Command or Action	Purpose
	Device(config-router)# neighbor 172.16.12.1 weight 50	a default weight of 0; routes sourced by the local router have a default weight of 32768.
<b>Step 6</b>	<b>default-metric</b> <i>number</i> <b>Example:</b>  Device(config-router)# default-metric 300	(Optional) Sets a MED metric to set preferred paths to external neighbors. All routes without a MED will also be set to this value. The range is 1 to 4294967295. The lowest value is the most desirable.
<b>Step 7</b>	<b>bgp bestpath med missing-as-worst</b> <b>Example:</b>  Device(config-router)# bgp bestpath med missing-as-worst	(Optional) Configures the switch to consider a missing MED as having a value of infinity, making the path without a MED value the least desirable path.
<b>Step 8</b>	<b>bgp always-compare med</b> <b>Example:</b>  Device(config-router)# bgp always-compare-med	(Optional) Configures the switch to compare MEDs for paths from neighbors in different autonomous systems. By default, MED comparison is only done among paths in the same AS.
<b>Step 9</b>	<b>bgp bestpath med confed</b> <b>Example:</b>  Device(config-router)# bgp bestpath med confed	(Optional) Configures the switch to consider the MED in choosing a path from among those advertised by different subautonomous systems within a confederation.
<b>Step 10</b>	<b>bgp deterministic med</b> <b>Example:</b>  Device(config-router)# bgp deterministic med	(Optional) Configures the switch to consider the MED variable when choosing among routes advertised by different peers in the same AS.
<b>Step 11</b>	<b>bgp default local-preference</b> <i>value</i> <b>Example:</b>  Device(config-router)# bgp default local-preference 200	(Optional) Change the default local preference value. The range is 0 to 4294967295; the default value is 100. The highest local preference value is preferred.
<b>Step 12</b>	<b>maximum-paths</b> <i>number</i> <b>Example:</b>  Device(config-router)# maximum-paths 8	(Optional) Configures the number of paths to be added to the IP routing table. The default is to only enter the best path in the routing table. The range is from 1 to 16. Having multiple paths allows load-balancing among the paths. (Although the switch software allows a maximum of 32 equal-cost routes, the switch hardware will never use more than 16 paths per route.)

	Command or Action	Purpose
<b>Step 13</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 14</b>	<b>show ip bgp</b> <b>Example:</b>  Device# show ip bgp	Verifies the reset by checking information about the routing table and about BGP neighbors.
<b>Step 15</b>	<b>show ip bgp neighbors</b> <b>Example:</b>  Device# show ip bgp neighbors	Verifies the reset by checking information about the routing table and about BGP neighbors.
<b>Step 16</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring BGP Filtering with Route Maps

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>route-map map-tag [permit   deny]</b> <b>[sequence-number]</b> <b>Example:</b>  Device(config)# route-map set-peer-address permit 10	Creates a route map, and enter route-map configuration mode.
<b>Step 3</b>	<b>set ip next-hop ip-address [...ip-address]</b> <b>[peer-address]</b> <b>Example:</b>	(Optional) Sets a route map to disable next-hop processing <ul style="list-style-type: none"> <li>• In an inbound route map, set the next hop of matching routes to be the neighbor</li> </ul>

	Command or Action	Purpose
	Device(config)# set ip next-hop 10.1.1.3	<p>peering address, overriding third-party next hops.</p> <ul style="list-style-type: none"> <li>In an outbound route map of a BGP peer, set the next hop to the peering address of the local router, disabling the next-hop calculation.</li> </ul>
<b>Step 4</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 5</b>	<p><b>show route-map</b> [<i>map-name</i>]</p> <p><b>Example:</b></p> <pre>Device# show route-map</pre>	Displays all route maps configured or only the one specified to verify configuration.
<b>Step 6</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring BGP Filtering by Neighbor

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<p><b>router bgp</b> <i>autonomous-system</i></p> <p><b>Example:</b></p> <pre>Device(config)# router bgp 109</pre>	Enables a BGP routing process, assign it an AS number, and enter router configuration mode.
<b>Step 3</b>	<p><b>neighbor</b> {<i>ip-address</i>   <i>peer-group name</i>}</p> <p><b>distribute-list</b> {<i>access-list-number</i>   <i>name</i>}</p> <p>{<b>in</b>   <b>out</b>}</p>	(Optional) Filters BGP routing updates to or from neighbors as specified in an access list.

	Command or Action	Purpose
	<b>Example:</b>  Device(config-router)# neighbor 172.16.4.1 distribute-list 39 in	<b>Note</b> You can also use the <b>neighbor prefix-list</b> router configuration command to filter updates, but you cannot use both commands to configure the same BGP peer.
<b>Step 4</b>	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group name</i> } <b>route-map</b> <i>map-tag</i> { <b>in</b>   <b>out</b> }  <b>Example:</b>  Device(config-router)# neighbor 172.16.70.24 route-map internal-map in	(Optional) Applies a route map to filter an incoming or outgoing route.
<b>Step 5</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show ip bgp neighbors</b>  <b>Example:</b>  Device# show ip bgp neighbors	Verifies the configuration.
<b>Step 7</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring BGP Filtering by Access Lists and Neighbors

Another method of filtering is to specify an access list filter on both incoming and outbound updates, based on the BGP autonomous system paths. Each filter is an access list based on regular expressions. To use this method, define an autonomous system path access list, and apply it to updates to and from particular neighbors.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>ip as-path access-list</b> <i>access-list-number</i> { <b>permit</b>   <b>deny</b> } <i>as-regular-expressions</i>  <b>Example:</b>  Device(config)# ip as-path access-list 1 deny _65535_	Defines a BGP-related access list.
<b>Step 3</b>	<b>router bgp</b> <i>autonomous-system</i>  <b>Example:</b>  Device(config)# router bgp 110	Enters BGP router configuration mode.
<b>Step 4</b>	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group name</i> } <b>filter-list</b> { <i>access-list-number</i>   <i>name</i> } { <b>in</b>   <b>out</b>   <b>weight</b> <i>weight</i> }  <b>Example:</b>  Device(config-router)# neighbor 172.16.1.1 filter-list 1 out	Establishes a BGP filter based on an access list.
<b>Step 5</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show ip bgp neighbors</b> [ <b>paths</b> <i>regular-expression</i> ]  <b>Example:</b>  Device# show ip bgp neighbors	Verifies the configuration.
<b>Step 7</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring Prefix Lists for BGP Filtering

You do not need to specify a sequence number when removing a configuration entry. **Show** commands include the sequence numbers in their output.

Before using a prefix list in a command, you must set up the prefix list.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>ip prefix-list list-name [seq seq-value] deny   permit network/len [ge ge-value] [le le-value]</b> <b>Example:</b> Device(config)# ip prefix-list BLUE permit 172.16.1.0/24	Creates a prefix list with an optional sequence number to <b>deny</b> or <b>permit</b> access for matching conditions. You must enter at least one <b>permit</b> or <b>deny</b> clause. <ul style="list-style-type: none"> <li>• <i>network/len</i> is the network number and length (in bits) of the network mask.</li> <li>• (Optional) <b>ge</b> and <b>le</b> values specify the range of the prefix length to be matched. The specified <i>ge-value</i> and <i>le-value</i> must satisfy this condition: <math>len &lt; ge-value &lt; le-value &lt; 32</math></li> </ul>
<b>Step 3</b>	<b>ip prefix-list list-name seq seq-value deny   permit network/len [ge ge-value] [le le-value]</b> <b>Example:</b> Device(config)# ip prefix-list BLUE seq 10 permit 172.24.1.0/24	(Optional) Adds an entry to a prefix list, and assign a sequence number to the entry.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show ip prefix list [detail   summary] name [network/len] [seq seq-num] [longer] [first-match]</b> <b>Example:</b> Device# show ip prefix list summary test	Verifies the configuration by displaying information about a prefix list or prefix list entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring BGP Community Filtering

By default, no COMMUNITIES attribute is sent to a neighbor. You can specify that the COMMUNITIES attribute be sent to the neighbor at an IP address by using the **neighbor send-community** router configuration command.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>ip community-list <i>community-list-number</i> {permit   deny} <i>community-number</i></b> <b>Example:</b> Device(config)# ip community-list 1 permit 50000:10	Creates a community list, and assigns it a number. <ul style="list-style-type: none"> <li>• The <i>community-list-number</i> is an integer from 1 to 99 that identifies one or more permit or deny groups of communities.</li> <li>• The <i>community-number</i> is the number configured by a <b>set community</b> route-map configuration command.</li> </ul>
<b>Step 3</b>	<b>router bgp <i>autonomous-system</i></b> <b>Example:</b> Device(config)# router bgp 108	Enters BGP router configuration mode.
<b>Step 4</b>	<b>neighbor {<i>ip-address</i>   <i>peer-group name</i>} send-community</b> <b>Example:</b> Device(config-router)# neighbor 172.16.70.23 send-community	Specifies that the COMMUNITIES attribute be sent to the neighbor at this IP address.
<b>Step 5</b>	<b>set comm-list <i>list-num</i> delete</b> <b>Example:</b> Device(config-router)# set comm-list 500 delete	(Optional) Removes communities from the community attribute of an inbound or outbound update that match a standard or extended community list specified by a route map.
<b>Step 6</b>	<b>exit</b> <b>Example:</b> Device(config-router)# end	Returns to global configuration mode.



	Command or Action	Purpose
<b>Step 7</b>	<b>ip bgp-community new-format</b> <b>Example:</b> <pre>Device(config)# ip bgp-community new format</pre>	(Optional) Displays and parses BGP communities in the format AA:NN.  A BGP community is displayed in a two-part format 2 bytes long. The Cisco default community format is in the format NNAA. In the most recent RFC for BGP, a community takes the form AA:NN, where the first part is the AS number and the second part is a 2-byte number.
<b>Step 8</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 9</b>	<b>show ip bgp community</b> <b>Example:</b> <pre>Device# show ip bgp community</pre>	Verifies the configuration.
<b>Step 10</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring BGP Neighbors and Peer Groups

To assign configuration options to an individual neighbor, specify any of these router configuration commands by using the neighbor IP address. To assign the options to a peer group, specify any of the commands by using the peer group name. You can disable a BGP peer or peer group without removing all the configuration information by using the **neighbor shutdown** router configuration command.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<b>router bgp <i>autonomous-system</i></b>	Enters BGP router configuration mode.
<b>Step 3</b>	<b>neighbor <i>peer-group-name</i> peer-group</b>	Creates a BGP peer group.

	Command or Action	Purpose
Step 4	<b>neighbor</b> <i>ip-address</i> <b>peer-group</b> <i>peer-group-name</i>	Makes a BGP neighbor a member of the peer group.
Step 5	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>remote-as</b> <i>number</i>	Specifies a BGP neighbor. If a peer group is not configured with a <b>remote-as</b> <i>number</i> , use this command to create peer groups containing EBGP neighbors. The range is 1 to 65535.
Step 6	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>description</b> <i>text</i>	(Optional) Associates a description with a neighbor.
Step 7	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>default-originate</b> [ <b>route-map</b> <i>map-name</i> ]	(Optional) Allows a BGP speaker (the local router) to send the default route 0.0.0.0 to a neighbor for use as a default route.
Step 8	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>send-community</b>	(Optional) Specifies that the COMMUNITIES attribute be sent to the neighbor at this IP address.
Step 9	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>update-source</b> <i>interface</i>	(Optional) Allows internal BGP sessions to use any operational interface for TCP connections.
Step 10	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>ebgp-multihop</b>	(Optional) Allows BGP sessions, even when the neighbor is not on a directly connected segment. The multihop session is not established if the only route to the multihop peer's address is the default route (0.0.0.0).
Step 11	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>local-as</b> <i>number</i>	(Optional) Specifies an AS number to use as the local AS. The range is 1 to 65535.
Step 12	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>advertisement-interval</b> <i>seconds</i>	(Optional) Sets the minimum interval between sending BGP routing updates.
Step 13	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>maximum-prefix</b> <i>maximum</i> [ <i>threshold</i> ]	(Optional) Controls how many prefixes can be received from a neighbor. The range is 1 to 4294967295. The <i>threshold</i> (optional) is the percentage of maximum at which a warning message is generated. The default is 75 percent.
Step 14	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>next-hop-self</b>	(Optional) Disables next-hop processing on the BGP updates to a neighbor.
Step 15	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>password</b> <i>string</i>	(Optional) Sets MD5 authentication on a TCP connection to a BGP peer. The same password must be configured on both BGP peers, or the connection between them is not made.
Step 16	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>route-map</b> <i>map-name</i> { <b>in</b>   <b>out</b> }	(Optional) Applies a route map to incoming or outgoing routes.

	Command or Action	Purpose
Step 17	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>send-community</b>	(Optional) Specifies that the COMMUNITIES attribute be sent to the neighbor at this IP address.
Step 18	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>timers</b> <i>keepalive holdtime</i>	(Optional) Sets timers for the neighbor or peer group. <ul style="list-style-type: none"> <li>The <i>keepalive</i> interval is the time within which keepalive messages are sent to peers. The range is 1 to 4294967295 seconds; the default is 60.</li> <li>The <i>holdtime</i> is the interval after which a peer is declared inactive after not receiving a keepalive message from it. The range is 1 to 4294967295 seconds; the default is 180.</li> </ul>
Step 19	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>weight</b> <i>weight</i>	(Optional) Specifies a weight for all routes from a neighbor.
Step 20	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>distribute-list</b> { <i>access-list-number</i>   <i>name</i> } { <b>in</b>   <b>out</b> }	(Optional) Filter BGP routing updates to or from neighbors, as specified in an access list.
Step 21	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>filter-list</b> <i>access-list-number</i> { <b>in</b>   <b>out</b>   <b>weight</b> <i>weight</i> }	(Optional) Establish a BGP filter.
Step 22	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>version</b> <i>value</i>	(Optional) Specifies the BGP version to use when communicating with a neighbor.
Step 23	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>soft-reconfiguration inbound</b>	(Optional) Configures the software to start storing received updates.
Step 24	<b>end</b> <b>Example:</b>  Device (config) # <b>end</b>	Returns to privileged EXEC mode.
Step 25	<b>show ip bgp neighbors</b>	Verifies the configuration.
Step 26	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring Aggregate Addresses in a Routing Table

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>router bgp <i>autonomous-system</i></b> <b>Example:</b>  Device(config)# <b>router bgp 106</b>	Enters BGP router configuration mode.
<b>Step 3</b>	<b>aggregate-address <i>address mask</i></b> <b>Example:</b>  Device(config-router)# <b>aggregate-address 10.0.0.0 255.0.0.0</b>	Creates an aggregate entry in the BGP routing table. The aggregate route is advertised as coming from the AS, and the atomic aggregate attribute is set to indicate that information might be missing.
<b>Step 4</b>	<b>aggregate-address <i>address mask as-set</i></b> <b>Example:</b>  Device(config-router)# <b>aggregate-address 10.0.0.0 255.0.0.0 as-set</b>	(Optional) Generates AS set path information. This command creates an aggregate entry following the same rules as the previous command, but the advertised path will be an AS_SET consisting of all elements contained in all paths. Do not use this keyword when aggregating many paths because this route must be continually withdrawn and updated.
<b>Step 5</b>	<b>aggregate-address <i>address-mask summary-only</i></b> <b>Example:</b>  Device(config-router)# <b>aggregate-address 10.0.0.0 255.0.0.0 summary-only</b>	(Optional) Advertises summary addresses only.
<b>Step 6</b>	<b>aggregate-address <i>address mask suppress-map map-name</i></b> <b>Example:</b>  Device(config-router)# <b>aggregate-address 10.0.0.0 255.0.0.0 suppress-map map1</b>	(Optional) Suppresses selected, more specific routes.
<b>Step 7</b>	<b>aggregate-address <i>address mask advertise-map map-name</i></b> <b>Example:</b>	(Optional) Generates an aggregate based on conditions specified by the route map.

	Command or Action	Purpose
	Device(config-router)# aggregate-address 10.0.0.0 255.0.0.0 advertise-map map2	
<b>Step 8</b>	<b>aggregate-address</b> <i>address mask</i> <b>attribute-map</b> <i>map-name</i>  <b>Example:</b>  Device(config-router)# aggregate-address 10.0.0.0 255.0.0.0 attribute-map map3	(Optional) Generates an aggregate with attributes specified in the route map.
<b>Step 9</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 10</b>	<b>show ip bgp neighbors</b> [ <i>advertised-routes</i> ]  <b>Example:</b>  Device# show ip bgp neighbors	Verifies the configuration.
<b>Step 11</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring Routing Domain Confederations

You must specify a confederation identifier that acts as the autonomous system number for the group of autonomous systems.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>router bgp</b> <i>autonomous-system</i>  <b>Example:</b>  Device(config)# <b>router bgp</b> 100	Enters BGP router configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>bgp confederation identifier</b> <i>autonomous-system</i>  <b>Example:</b>  Device(config)# bgp confederation identifier 50007	Configures a BGP confederation identifier.
<b>Step 4</b>	<b>bgp confederation peers</b> <i>autonomous-system</i> <i>[autonomous-system ...]</i>  <b>Example:</b>  Device(config)# bgp confederation peers 51000 51001 51002	Specifies the autonomous systems that belong to the confederation and that will be treated as special EBGp peers.
<b>Step 5</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show ip bgp neighbor</b>  <b>Example:</b>  Device# show ip bgp neighbor	Verifies the configuration.
<b>Step 7</b>	<b>show ip bgp network</b>  <b>Example:</b>  Device# show ip bgp network	Verifies the configuration.
<b>Step 8</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring BGP Route Reflectors

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 2</b>	<b>router bgp</b> <i>autonomous-system</i> <b>Example:</b> Device(config)# <code>router bgp 101</code>	Enters BGP router configuration mode.
<b>Step 3</b>	<b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i> } <b>route-reflector-client</b> <b>Example:</b> Device(config-router)# <code>neighbor 172.16.70.24 route-reflector-client</code>	Configures the local router as a BGP route reflector and the specified neighbor as a client.
<b>Step 4</b>	<b>bgp cluster-id</b> <i>cluster-id</i> <b>Example:</b> Device(config-router)# <code>bgp cluster-id 10.0.1.2</code>	(Optional) Configures the cluster ID if the cluster has more than one route reflector.
<b>Step 5</b>	<b>no bgp client-to-client reflection</b> <b>Example:</b> Device(config-router)# <code>no bgp client-to-client reflection</code>	(Optional) Disables client-to-client route reflection. By default, the routes from a route reflector client are reflected to other clients. However, if the clients are fully meshed, the route reflector does not need to reflect routes to clients.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show ip bgp</b> <b>Example:</b> Device# <code>show ip bgp</code>	Verifies the configuration. Displays the originator ID and the cluster-list attributes.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring Route Dampening

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>router bgp <i>autonomous-system</i></b> <b>Example:</b>  Device(config)# <b>router bgp 100</b>	Enters BGP router configuration mode.
<b>Step 3</b>	<b>bgp dampening</b> <b>Example:</b>  Device(config-router)# <b>bgp dampening</b>	Enables BGP route dampening.
<b>Step 4</b>	<b>bgp dampening <i>half-life reuse suppress max-suppress [route-map map]</i></b> <b>Example:</b>  Device(config-router)# <b>bgp dampening 30 1500 10000 120</b>	(Optional) Changes the default values of route dampening factors.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show ip bgp flap-statistics [ {<i>regexp regexp</i>}   {<i>filter-list list</i>}   {<i>address mask</i>} [ {<i>longer-prefix</i>} ] ]</b> <b>Example:</b>  Device# <b>show ip bgp flap-statistics</b>	(Optional) Monitors the flaps of all paths that are flapping. The statistics are deleted when the route is not suppressed and is stable.
<b>Step 7</b>	<b>show ip bgp dampened-paths</b> <b>Example:</b>  Device# <b>show ip bgp dampened-paths</b>	(Optional) Displays the dampened routes, including the time remaining before they are suppressed.
<b>Step 8</b>	<b>clear ip bgp flap-statistics [ {<i>regexp regexp</i>}   {<i>filter-list list</i>}   {<i>address mask</i>} [ {<i>longer-prefix</i>} ] ]</b>	(Optional) Clears BGP flap statistics to make it less likely that a route will be dampened.



	Command or Action	Purpose
	<b>Example:</b> Device# <code>clear ip bgp flap-statistics</code>	
<b>Step 9</b>	<b>clear ip bgp dampening</b> <b>Example:</b> Device# <code>clear ip bgp dampening</code>	(Optional) Clears route dampening information, and unsuppress the suppressed routes.
<b>Step 10</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Monitoring and Maintaining BGP

You can remove all contents of a particular cache, table, or database. This might be necessary when the contents of the particular structure have become or are suspected to be invalid.

You can display specific statistics, such as the contents of BGP routing tables, caches, and databases. You can use the information to get resource utilization and solve network problems. You can also display information about node reachability and discover the routing path your device's packets are taking through the network.

The table given below lists the privileged EXEC commands for clearing and displaying BGP.

**Table 119: IP BGP Clear and Show Commands**

<b>clear ip bgp <i>address</i></b>	Resets a particular BGP connection.
<b>clear ip bgp *</b>	Resets all BGP connections.
<b>clear ip bgp peer-group <i>tag</i></b>	Removes all members of a BGP peer group.
<b>show ip bgp <i>prefix</i></b>	Displays peer groups and peers not in peer groups to which the prefix has been advertised. Also displays prefix attributes such as the next hop and the local prefix.
<b>show ip bgp cidr-only</b>	Displays all BGP routes that contain subnet and supernet network masks.
<b>show ip bgp community [<i>community-number</i>] [<b>exact</b>]</b>	Displays routes that belong to the specified communities.
<b>show ip bgp community-list <i>community-list-number</i> [<b>exact-match</b>]</b>	Displays routes that are permitted by the community list.

<b>show ip bgp filter-list</b> <i>access-list-number</i>	Displays routes that are matched by the specified AS path access list.
<b>show ip bgp inconsistent-as</b>	Displays the routes with inconsistent originating autonomous systems.
<b>show ip bgp regexp</b> <i>regular-expression</i>	Displays the routes that have an AS path that matches the specified regular expression entered on the command line.
<b>show ip bgp</b>	Displays the contents of the BGP routing table.
<b>show ip bgp neighbors</b> [ <i>address</i> ]	Displays detailed information on the BGP and TCP connections to individual neighbors.
<b>show ip bgp neighbors</b> [ <i>address</i> ] [ <b>advertised-routes</b>   <b>dampened-routes</b>   <b>flap-statistics</b>   <b>paths</b>   <i>regular-expression</i>   <b>received-routes</b>   <b>routes</b> ]	Displays routes learned from a particular BGP neighbor.
<b>show ip bgp paths</b>	Displays all BGP paths in the database.
<b>show ip bgp peer-group</b> [ <i>tag</i> ] [ <b>summary</b> ]	Displays information about BGP peer groups.
<b>show ip bgp summary</b>	Displays the status of all BGP connections.

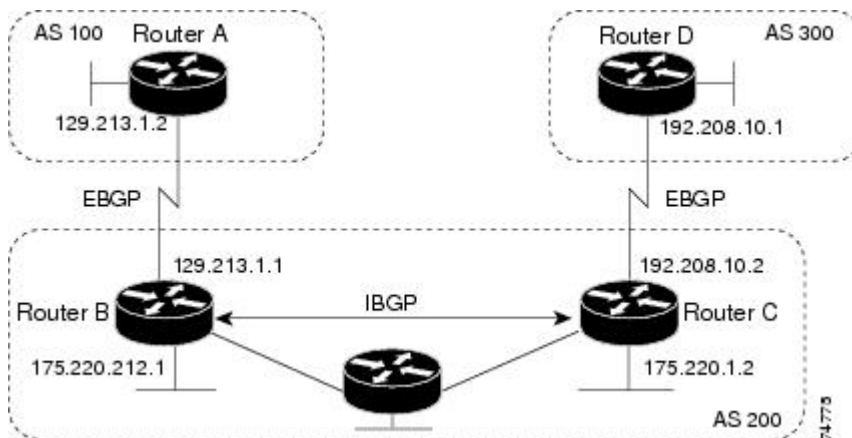
The **bgp log-neighbor changes** command is enabled by default. It allows to log messages that are generated when a BGP neighbor resets, comes up, or goes down.

## Configuration Examples for BGP

### Example: Configuring BGP on Routers

These examples show how to configure BGP on the routers in the figure below,

**Figure 102: EBGP, IBGP, and Multiple Autonomous Systems**



Router A:

```
Device(config)# router bgp 100
Device(config-router)# neighbor 129.213.1.1 remote-as 200
```

Router B:

```
Device(config)# router bgp 200
Device(config-router)# neighbor 129.213.1.2 remote-as 100
Device(config-router)# neighbor 175.220.1.2 remote-as 200
```

Router C:

```
Device(config)# router bgp 200
Device(config-router)# neighbor 175.220.212.1 remote-as 200
Device(config-router)# neighbor 192.208.10.1 remote-as 300
```

Router D:

```
Device(config)# router bgp 300
Device(config-router)# neighbor 192.208.10.2 remote-as 200
```

To verify that BGP peers are running, use the `show ip bgp neighbors` privileged EXEC command. This is the output of this command on Router A:

```
Device# show ip bgp neighbors

BGP neighbor is 129.213.1.1, remote AS 200, external link
  BGP version 4, remote router ID 175.220.212.1
  BGP state = established, table version = 3, up for 0:10:59
  Last read 0:00:29, hold time is 180, keepalive interval is 60 seconds
  Minimum time between advertisement runs is 30 seconds
  Received 2828 messages, 0 notifications, 0 in queue
  Sent 2826 messages, 0 notifications, 0 in queue
  Connections established 11; dropped 10
```

Anything other than `state = established` means that the peers are not running. The remote router ID is the highest IP address on that router (or the highest loopback interface). Each time the table is updated with new information, the table version number increments. A table version number that continually increments means that a route is flapping, causing continual routing updates.

For exterior protocols, a reference to an IP network from the **network** router configuration command controls only which networks are advertised. This is in contrast to Interior Gateway Protocols (IGPs), such as EIGRP, which also use the **network** command to specify where to send updates.

## Information About ISO CLNS Routing

### Connectionless Routing

The International Organization for Standardization (ISO) Connectionless Network Service (CLNS) protocol is a standard for the network layer of the Open System Interconnection (OSI) model. Addresses in the ISO network architecture are referred to as network service access point (NSAP) addresses and network entity titles (NETs). Each node in an OSI network has one or more NETs. In addition, each node has many NSAP addresses.

When you enable connectionless routing on the Device by using the **clns routing** global configuration command, the Device makes only forwarding decisions, with no routing-related functionality. For dynamic routing, you must also enable a routing protocol. The Device supports the Intermediate System-to-Intermediate System (IS-IS) dynamic routing protocol that is based on the OSI routing protocol for ISO CLNS networks.

When dynamically routing, you use IS-IS. This routing protocol supports the concept of areas. Within an area, all routers know how to reach all the system IDs. Between areas, routers know how to reach the proper area. IS-IS supports two levels of routing: station routing (within an area) and area routing (between areas).

The key difference between the ISO IGRP and IS-IS NSAP addressing schemes is in the definition of area addresses. Both use the system ID for Level 1 routing (routing within an area). However, they differ in the way addresses are specified for area routing. An ISO IGRP NSAP address includes three separate fields for routing: the domain, area, and system ID. An IS-IS address includes two fields: a single continuous area field (comprising the domain and area fields) and the system ID.

## Information About IS-IS Routing

Integrated Intermediate System-to-Intermediate System (IS-IS) is an ISO dynamic routing protocol (described in ISO 105890). To enable IS-IS you should create an IS-IS routing process and assign it to a specific interface, rather than to a network. You can specify more than one IS-IS routing process per Layer 3 device by using the multiarea IS-IS configuration syntax. You should then configure the parameters for each instance of the IS-IS routing process.

Small IS-IS networks are built as a single area that includes all the devices in the network. As the network grows larger, the network reorganizes itself into a backbone area made up of all the connected set of Level 2 devices still connected to their local areas. Within a local area, devices know how to reach all system IDs. Between areas, devices know how to reach the backbone, and the backbone devices know how to reach other areas.

Devices establish Level 1 adjacencies to perform routing within a local area (station routing). Devices establish Level 2 adjacencies to perform routing between Level 1 areas (area routing).

A single Cisco device can participate in routing in up to 29 areas and can perform Level 2 routing in the backbone. In general, each routing process corresponds to an area. By default, the first instance of the routing process that is configured performs both Level 1 and Level 2 routing. You can configure additional device instances, which are automatically treated as Level 1 areas. You must configure the parameters for each instance of the IS-IS routing process individually.

For IS-IS multiarea routing, you can configure only one process to perform Level 2 routing, although you can define up to 29 Level 1 areas for each Cisco unit. If Level 2 routing is configured on any process, all additional processes are automatically configured as Level 1. You can configure this process to perform Level 1 routing at the same time. If Level 2 routing is not desired for a device instance, remove the Level 2 capability using the **is-type** command in global configuration mode. Use the **is-type** command also to configure a different device instance as a Level 2 device.

## Nonstop Forwarding Awareness

The integrated IS-IS Nonstop Forwarding (NSF) Awareness feature is supported for IPv4G. The feature allows customer premises equipment (CPE) devices that are NSF-aware to help NSF-capable devices perform nonstop forwarding of packets. The local device is not necessarily performing NSF, but its NSF awareness capability allows the integrity and accuracy of the routing database and the link-state database on the neighboring NSF-capable device to be maintained during the switchover process.

The integrated IS-IS Nonstop Forwarding (NSF) Awareness feature is automatically enabled and requires no configuration.

## IS-IS Global Parameters

The following are the optional IS-IS global parameters that you can configure:

- You can force a default route into an IS-IS routing domain by configuring a default route that is controlled by a route map. You can also specify the other filtering options that are configurable under a route map.
- You can configure the device to ignore IS-IS link-state packets (LSPs) that are received with internal checksum errors, or to purge corrupted LSPs, and cause the initiator of the LSP to regenerate it.
- You can assign passwords to areas and domains.
- You can create aggregate addresses that are represented in the routing table by a summary address (based on route summarization). Routes learned from other routing protocols can also be summarized. The metric used to advertise the summary is the smallest metric of all the specific routes.
- You can set an overload bit.
- You can configure the LSP refresh interval and the maximum time that an LSP can remain in the device database without a refresh.
- You can set the throttling timers for LSP generation, shortest path first computation, and partial route computation.
- You can configure the device to generate a log message when an IS-IS adjacency changes state (Up or Down).
- If a link in the network has a maximum transmission unit (MTU) size of less than 1500 bytes, you can lower the LSP MTU so that routing still occurs.
- You can use the **partition avoidance** command to prevent an area from becoming partitioned when full connectivity is lost among a Level 1-2 border device, adjacent Level 1 devices, and end hosts.

## IS-IS Interface Parameters

You can optionally configure certain interface-specific IS-IS parameters independently from other attached devices. However, if you change default value, such as multipliers and time intervals, it makes sense to also change them on multiple devices and interfaces. Most of the interface parameters can be configured for level 1, level 2, or both.

The following are the interface-level parameters that you can configure:

- The default metric on the interface that is used as a value for the IS-IS metric and assigned when quality of service (QoS) routing is not performed.
- The hello interval (length of time between hello packets sent on the interface) or the default hello packet multiplier used on the interface to determine the hold time sent in IS-IS hello packets. The hold time determines how long a neighbor waits for another hello packet before declaring the neighbor down. This determines how quickly a failed link or neighbor is detected so that routes can be recalculated. Change the hello multiplier in circumstances where hello packets are lost frequently and IS-IS adjacencies are failing unnecessarily. You can raise the hello multiplier and lower the hello interval correspondingly to make the hello protocol more reliable, without increasing the time required to detect a link failure.

- Other time intervals:
  - Complete sequence number PDU (CSNP) interval—CSNPs are sent by the designated device to maintain database synchronization.
  - Retransmission interval—This is the time between retransmission of IS-IS LSPs for point-to-point links.
  - IS-IS LSP retransmission throttle interval—This is the maximum rate (number of milliseconds between packets) at which IS-IS LSPs are resent on point-to-point links. This interval is different from the retransmission interval, which is the time between successive retransmissions of the same LSP.
- Designated device-election priority, which allows you to reduce the number of adjacencies required on a multiaccess network, which in turn reduces the amount of routing protocol traffic and the size of the topology database.
- The interface circuit type, which is the type of adjacency required for neighbors on the specified interface.
- Password authentication for the interface.

## How to Configure ISO CLNS Routing

### Default IS-IS Configuration

*Table 120: Default IS-IS Configuration*

Feature	Default Setting
Ignore link-state PDU (LSP) errors	Enabled.
IS-IS type	Conventional IS-IS—The router acts as both a Level 1 (station) and a Level 2 (area) router.  Multiarea IS-IS—The first instance of the IS-IS routing process is a Level 1-2 router. Remaining instances are Level 1 routers.
Default-information originate	Disabled.
Log IS-IS adjacency state changes.	Disabled.
LSP generation throttling timers	Maximum interval between two consecutive occurrences—5 seconds.  Initial LSP generation delay—50 ms.  Hold time between the first and second LSP generation—5000 ms.
LSP maximum lifetime (without a refresh)	1200 seconds (20 minutes) before the LSP packet is deleted.

Feature	Default Setting
LSP refresh interval	Every 900 seconds (15 minutes).
Maximum LSP packet size	1497 bytes.
NSF Awareness	Enabled. Allows Layer 3 devices to continue forwarding packets from a neighboring Nonstop Forwarding-capable router during hardware or software changes.
Partial route computation (PRC) throttling timers	Maximum PRC wait interval—5 seconds. Initial PRC calculation delay after a topology change—2000 ms. Hold time between the first and second PRC calculation—5000 ms.
Partition avoidance	Disabled.
Password	No area or domain password is defined, and authentication is disabled.
Set-overload-bit	Disabled. When enabled, if no arguments are entered, the overload bit is set immediately and remains set until you enter the <b>no set-overload-bit</b> command.
Shortest path first (SPF) throttling timers	Maximum interval between consecutive SFPS—10 seconds. Initial SFP calculation after a topology change—5500 ms. Hold time between the first and second SFP calculation—5500 ms.
Summary-address	Disabled.

## Enabling IS-IS Routing

To enable IS-IS, you specify a name and network entity title (NET) for each routing process. You then enable IS-IS routing on the interface and specify the area for each instance of the routing process.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>clns routing</b> <b>Example:</b> <pre>Device(config)# clns routing</pre>	Enables ISO connectionless routing on the switch.
<b>Step 3</b>	<b>router isis [area tag]</b> <b>Example:</b> <pre>Device(config)# router isis tag1</pre>	<p>Enables the IS-IS routing for the specified routing process and enter IS-IS routing configuration mode.</p> <p>(Optional) Use the <i>area tag</i> argument to identify the area to which the IS-IS router is assigned. You must enter a value if you are configuring multiple IS-IS areas.</p> <p>The first IS-IS instance configured is Level 1-2 by default. Later instances are automatically Level 1. You can change the level of routing by using the <b>is-type</b> global configuration command.</p>
<b>Step 4</b>	<b>net network-entity-title</b> <b>Example:</b> <pre>Device(config-router)# net 47.0004.004d.0001.0001.0c11.1111.00</pre>	Configures the NETs for the routing process. If you are configuring multiarea IS-IS, specify a NET for each routing process. You can specify a name for a NET and for an address.
<b>Step 5</b>	<b>is-type {level-1   level-1-2   level-2-only}</b> <b>Example:</b> <pre>Device(config-router)# is-type level-2-only</pre>	<p>(Optional) Configures the router to act as a Level 1 (station) router, a Level 2 (area) router for multi-area routing, or both (the default):</p> <ul style="list-style-type: none"> <li>• <b>level-1</b>—Acts as a station router only.</li> <li>• <b>level-1-2</b>—Acts as both a station router and an area router.</li> <li>• <b>level 2</b>—Acts as an area router only.</li> </ul>
<b>Step 6</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-router)# end</pre>	Returns to global configuration mode.
<b>Step 7</b>	<b>interface interface-id</b> <b>Example:</b> <pre>Device(config)# interface gigabitethernet 1/0/1</pre>	Specifies an interface to route IS-IS, and enters interface configuration mode. If the interface is not already configured as a Layer 3 interface, enter the <b>no switchport</b> command to configure the interface into Layer 3 mode.



	Command or Action	Purpose
<b>Step 8</b>	<b>ip router isis</b> [ <i>area tag</i> ] <b>Example:</b>  Device(config-if)# ip router isis tag1	Configures an IS-IS routing process for ISO CLNS on the interface and attaches an area designator to the routing process.
<b>Step 9</b>	<b>clns router isis</b> [ <i>area tag</i> ] <b>Example:</b>  Device(config-if)# clns router isis tag1	Enables ISO CLNS on the interface.
<b>Step 10</b>	<b>ip address</b> <i>ip-address-mask</i> <b>Example:</b>  Device(config-if)# ip address 10.0.0.5 255.255.255.0	Defines the IP address for the interface. An IP address is required on all the interfaces in an area enabled for IS-IS if any one interface is configured for IS-IS routing.
<b>Step 11</b>	<b>end</b> <b>Example:</b>  Device(config)# end	Returns to privileged EXEC mode.
<b>Step 12</b>	<b>show isis</b> [ <i>area tag</i> ] <b>database detail</b> <b>Example:</b>  Device# show isis database detail	Verifies your entries.
<b>Step 13</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Configuring IS-IS Global Parameters

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>clns routing</b> <b>Example:</b>	Enables ISO connectionless routing on the switch.

	Command or Action	Purpose
	Device(config)# clns routing	
<b>Step 3</b>	<b>router isis</b> <b>Example:</b> Device(config)# router isis	Specifies the IS-IS routing protocol and enters router configuration mode.
<b>Step 4</b>	<b>default-information originate [route-map map-name]</b> <b>Example:</b> Device(config-router)# default-information originate route-map map1	(Optional) Forces a default route into the IS-IS routing domain. If you enter <b>route-map map-name</b> , the routing process generates the default route if the route map is satisfied.
<b>Step 5</b>	<b>ignore-lsp-errors</b> <b>Example:</b> Device(config-router)# ignore-lsp-errors	(Optional) Configures the router to ignore LSPs with internal checksum errors, instead of purging the LSPs. This command is enabled by default (corrupted LSPs are dropped). To purge the corrupted LSPs, enter the <b>no ignore-lsp-errors</b> router configuration command.
<b>Step 6</b>	<b>area-password password</b> <b>Example:</b> Device(config-router)# area-password lpassword	(Optional) Configures the area authentication password that is inserted in Level 1 (station router level) LSPs.
<b>Step 7</b>	<b>domain-password password</b> <b>Example:</b> Device(config-router)# domain-password 2password	(Optional) Configures the routing domain authentication password that is inserted in Level 2 (area router level) LSPs.
<b>Step 8</b>	<b>summary-address address mask [level-1   level-1-2   level-2]</b> <b>Example:</b> Device(config-router)# summary-address 10.1.0.0 255.255.0.0 level-2	(Optional) Creates a summary of addresses for a given level.
<b>Step 9</b>	<b>set-overload-bit [on-startup {seconds   wait-for-bgp}]</b> <b>Example:</b> Device(config-router)# set-overload-bit on-startup wait-for-bgp	(Optional) Sets an overload bit to allow other routers to ignore the router in their shortest path first (SPF) calculations if the router is having problems. <ul style="list-style-type: none"> <li>(Optional) <b>on-startup</b>—Sets the overload bit only on startup. If <b>on-startup</b> is not specified, the overload bit is set</li> </ul>

	Command or Action	Purpose
		<p>immediately and remains set until you enter the <b>no set-overload-bit</b> command. If <b>on-startup</b> is specified, you must either enter number of seconds or enter <b>wait-for-bgp</b>.</p> <ul style="list-style-type: none"> <li>• <b>seconds</b>—When the <b>on-startup</b> keyword is configured, it causes the overload bit to be set when the system is started and remains set for the specified number of seconds. The range is from 5 to 86400 seconds.</li> <li>• <b>wait-for-bgp</b>—When the <b>on-startup</b> keyword is configured, it causes the overload bit to be set when the system is started and remains set until BGP has converged. If BGP does not signal the IS-IS that it is converged, the IS-IS will turn off the overload bit after 10 minutes.</li> </ul>
<b>Step 10</b>	<p><b>lsp-refresh-interval</b> <i>seconds</i></p> <p><b>Example:</b></p> <pre>Device(config-router)# lsp-refresh-interval 1080</pre>	(Optional) Sets an LSP refresh interval, in seconds. The range is from 1 to 65535 seconds. The default is to send LSP refreshes every 900 seconds (15 minutes).
<b>Step 11</b>	<p><b>max-lsp-lifetime</b> <i>seconds</i></p> <p><b>Example:</b></p> <pre>Device(config-router)# max-lsp-lifetime 1000</pre>	(Optional) Sets the maximum time that LSP packets remain in the router database without being refreshed. The range is from 1 to 65535 seconds. The default is 1200 seconds (20 minutes). After the specified time interval, the LSP packet is deleted.
<b>Step 12</b>	<p><b>lsp-gen-interval</b> [<b>level-1</b>   <b>level-2</b>] <i>lsp-max-wait</i> [<i>lsp-initial-wait</i> <i>lsp-second-wait</i>]</p> <p><b>Example:</b></p> <pre>Device(config-router)# lsp-gen-interval level-2 2 50 100</pre>	<p>(Optional) Sets the IS-IS LSP generation throttling timers:</p> <ul style="list-style-type: none"> <li>• <b>lsp-max-wait</b>—Maximum interval (in seconds) between two consecutive occurrences of an LSP being generated. The range is from 1 to 120; the default is 5.</li> <li>• <b>lsp-initial-wait</b>—Initial LSP generation delay (in milliseconds). The range is from 1 to 10000; the default is 50.</li> <li>• <b>lsp-second-wait</b>—Hold time between the first and second LSP generation (in milliseconds). The range is from 1 to 10000; the default is 5000.</li> </ul>

	Command or Action	Purpose
<b>Step 13</b>	<p><b>spf-interval</b> [level-1   level-2] <i>spf-max-wait</i> [<i>spf-initial-wait</i> <i>spf-second-wait</i>]</p> <p><b>Example:</b></p> <pre>Device(config-router)# spf-interval level-2 5 10 20</pre>	<p>(Optional) Sets IS-IS SPF throttling timers.</p> <ul style="list-style-type: none"> <li>• <i>spf-max-wait</i>—Maximum interval between consecutive SFPs (in seconds). The range is from 1 to 120; the default is 10.</li> <li>• <i>spf-initial-wait</i>—Initial SFP calculation after a topology change (in milliseconds). The range is from 1 to 10000; the default is 5500.</li> <li>• <i>spf-second-wait</i>—Hold time between the first and second SFP calculation (in milliseconds). The range is from 1 to 10000; the default is 5500.</li> </ul>
<b>Step 14</b>	<p><b>prc-interval</b> <i>prc-max-wait</i> [<i>prc-initial-wait</i> <i>prc-second-wait</i>]</p> <p><b>Example:</b></p> <pre>Device(config-router)# prc-interval 5 10 20</pre>	<p>(Optional) Sets IS-IS PRC throttling timers.</p> <ul style="list-style-type: none"> <li>• <i>prc-max-wait</i>—Maximum interval (in seconds) between two consecutive PRC calculations. The range is from 1 to 120; the default is 5.</li> <li>• <i>prc-initial-wait</i>—Initial PRC calculation delay (in milliseconds) after a topology change. The range is from 1 to 10,000; the default is 2000.</li> <li>• <i>prc-second-wait</i>—Hold time between the first and second PRC calculation (in milliseconds). The range is 1 to 10,000; the default is 5000.</li> </ul>
<b>Step 15</b>	<p><b>log-adjacency-changes</b> [all]</p> <p><b>Example:</b></p> <pre>Device(config-router)# log-adjacency-changes all</pre>	<p>(Optional) Sets the router to log IS-IS adjacency state changes. Enter <b>all</b> to include all changes generated by events that are not related to the IS-IS hellos, including End System-to-Intermediate System PDUs and link state packets (LSPs).</p>
<b>Step 16</b>	<p><b>lsp-mtu</b> <i>size</i></p> <p><b>Example:</b></p> <pre>Device(config-router)# lsp mtu 1560</pre>	<p>(Optional) Specifies the maximum LSP packet size, in bytes. The range is from 128 to 4352; the default is 1497 bytes.</p> <p><b>Note</b> If a link in the network has a reduced MTU size, you must change the LSP MTU size on all the devices in the network.</p>

	Command or Action	Purpose
<b>Step 17</b>	<b>partition avoidance</b> <b>Example:</b>  Device(config-router)# partition avoidance	(Optional) Causes an IS-IS Level 1-2 border router to stop advertising the Level 1 area prefix into the Level 2 backbone when full connectivity is lost among the border router, all adjacent level 1 routers, and end hosts.
<b>Step 18</b>	<b>end</b> <b>Example:</b>  Device(config)# end	Returns to privileged EXEC mode.
<b>Step 19</b>	<b>show clns</b> <b>Example:</b>  Device# show clns	Verifies your entries.
<b>Step 20</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Configuring IS-IS Interface Parameters

To configure IS-IS interface-specific parameters, perform this procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>interface interface-id</b> <b>Example:</b>  Device(config)# interface gigabitethernet 1/0/1	Specifies the interface to be configured and enter interface configuration mode. If the interface is not already configured as a Layer 3 interface, enter the <b>no switchport</b> command to configure the interface in Layer 3 mode.
<b>Step 3</b>	<b>isis metric default-metric [level-1   level-2]</b> <b>Example:</b>  Device(config-if)# isis metric 15	(Optional) Configures the metric (or cost) for the specified interface. The range is from 0 to 63; the default is 10. If no level is entered, the default is to apply to both Level 1 and Level 2 routers.

	Command or Action	Purpose
<b>Step 4</b>	<p><b>isis hello-interval</b> <i>{seconds   minimal}</i> [level-1   level-2]</p> <p><b>Example:</b></p> <pre>Device(config-if)# isis hello-interval minimal</pre>	<p>(Optional) Specifies the length of time between the hello packets sent by the switch. By default, a value that is three times the hello interval <i>seconds</i> is advertised as the <i>holdtime</i> in the hello packets sent. With smaller hello intervals, topological changes are detected faster, but there is more routing traffic.</p> <ul style="list-style-type: none"> <li>• <b>minimal</b>—Causes the system to compute the hello interval based on the hello multiplier so that the resulting hold time is 1 second.</li> <li>• <i>seconds</i>—Range is from 1 to 65535; the default is 10 seconds.</li> </ul>
<b>Step 5</b>	<p><b>isis hello-multiplier</b> <i>multiplier</i> [level-1   level-2]</p> <p><b>Example:</b></p> <pre>Device(config-if)# isis hello-multiplier 5</pre>	<p>(Optional) Specifies the number of IS-IS hello packets a neighbor must miss before the device should declare the adjacency as down. The range is from 3 to 1000; the default is 3</p> <p><b>Note</b> Using a smaller hello multiplier causes fast convergence, but might result in routing instability.</p>
<b>Step 6</b>	<p><b>isis csnp-interval</b> <i>seconds</i> [level-1   level-2]</p> <p><b>Example:</b></p> <pre>Device(config-if)# isis csnp-interval 15</pre>	<p>(Optional) Configures the IS-IS complete sequence number PDU (CSNP) interval for the interface. The range is from 0 to 65535; the default is 10 seconds.</p>
<b>Step 7</b>	<p><b>isis retransmit-interval</b> <i>seconds</i></p> <p><b>Example:</b></p> <pre>Device(config-if)# isis retransmit-interval 7</pre>	<p>(Optional) Configures the number of seconds between the retransmission of IS-IS LSPs for point-to-point links. Specify an integer that is greater than the expected round-trip delay between any two routers on the network. The range is from 0 to 65535; the default is 5 seconds.</p>
<b>Step 8</b>	<p><b>isis retransmit-throttle-interval</b> <i>milliseconds</i></p> <p><b>Example:</b></p> <pre>Device(config-if)# isis retransmit-throttle-interval 4000</pre>	<p>(Optional) Configures the IS-IS LSP retransmission throttle interval, which is the maximum rate (number of milliseconds between packets) at which IS-IS LSPs will be resent on point-to-point links. The range is from 0 to 65535. The default is determined by the <b>isis lsp-interval</b> command.</p>

	Command or Action	Purpose
<b>Step 9</b>	<b>isis priority</b> <i>value</i> [ <b>level-1</b>   <b>level-2</b> ] <b>Example:</b> Device(config-if)# isis priority 50	(Optional) Configures the priority to use for the designated device. The range is from 0 to 127; the default is 64.
<b>Step 10</b>	<b>isis circuit-type</b> { <b>level-1</b>   <b>level-1-2</b>   <b>level-2-only</b> } <b>Example:</b> Device(config-if)# isis circuit-type level-1-2	(Optional) Configures the type of adjacency required for neighbors on the specified interface (specify the interface circuit type). <ul style="list-style-type: none"> <li>• <b>level-1</b>—Level 1 adjacency is established if there is at least one area address that is common to both this node and its neighbors.</li> <li>• <b>level-1-2</b>—Level 1 and Level 2 adjacency is established if the neighbor is also configured as both Level 1 and Level 2, and there is at least one area in common. If there is no area in common, a Level 2 adjacency is established. This is the default option.</li> <li>• <b>level 2</b>—Level 2 adjacency is established. If the neighbor router is a Level 1 router, no adjacency is established.</li> </ul>
<b>Step 11</b>	<b>isis password</b> <i>password</i> [ <b>level-1</b>   <b>level-2</b> ] <b>Example:</b> Device(config-if)# isis password secret	(Optional) Configures the authentication password for an interface. By default, authentication is disabled. Specifying Level 1 or Level 2 enables the password only for Level 1 or Level 2 routing, respectively. If you do not specify a level, the default is Level 1 and Level 2.
<b>Step 12</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 13</b>	<b>show clns interface</b> <i>interface-id</i> <b>Example:</b> Device# show clns interface gigabitethernet 1/0/1	Verifies your entries.
<b>Step 14</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Monitoring and Maintaining ISO IGRP and IS-IS

You can remove all contents of a CLNS cache or remove information for a particular neighbor or route. You can display specific CLNS or IS-IS statistics, such as the contents of routing tables, caches, and databases. You can also display information about specific interfaces, filters, or neighbors.

The following table lists the privileged EXEC commands for clearing and displaying ISO CLNS and IS-IS routing.

**Table 121: ISO CLNS and IS-IS Clear and Show Commands**

Command	Purpose
<b>clear clns cache</b>	Clears and reinitializes the CLNS routing cache.
<b>clear clns es-neighbors</b>	Removes end system (ES) neighbor information from the adjacency database.
<b>clear clns is-neighbors</b>	Removes intermediate system (IS) neighbor information from the adjacency database.
<b>clear clns neighbors</b>	Removes CLNS neighbor information from the adjacency database.
<b>clear clns route</b>	Removes dynamically derived CLNS routing information.
<b>show clns</b>	Displays information about the CLNS network.
<b>show clns cache</b>	Displays the entries in the CLNS routing cache.
<b>show clns es-neighbors</b>	Displays ES neighbor entries, including the associated areas.
<b>show clns filter-expr</b>	Displays filter expressions.
<b>show clns filter-set</b>	Displays filter sets.
<b>show clns interface</b> <i>[interface-id]</i>	Displays the CLNS-specific or ES-IS information about each interface.
<b>show clns neighbor</b>	Displays information about IS-IS neighbors.
<b>show clns protocol</b>	List the protocol-specific information for each IS-IS or ISO IGRP routing process in this router.
<b>show clns route</b>	Displays all the destinations to which this router knows how to route CLNS packets.
<b>show clns traffic</b>	Displays information about the CLNS packets this router has seen.
<b>show ip route isis</b>	Displays the current state of the ISIS IP routing table.



Command	Purpose
<b>show isis database</b>	Displays the IS-IS link-state database.
<b>show isis routes</b>	Displays the IS-IS Level 1 routing table.
<b>show isis spf-log</b>	Displays a history of the shortest path first (SPF) calculations for IS-IS.
<b>show isis topology</b>	Displays a list of all connected routers in all areas.
<b>show route-map</b>	Displays all route maps configured or only the one specified.
<b>trace clns destination</b>	Discover the paths taken to a specified destination by packets in the network.
<b>which-route</b> { <i>nsap-address</i>   <i>clns-name</i> }	Displays the routing table in which the specified CLNS destination is found.

## Configuration Examples for ISO CLNS Routing

### Example: Configuring IS-IS Routing

This example shows how to configure three routers to run conventional IS-IS as an IP routing protocol. In conventional IS-IS, all routers act as Level 1 and Level 2 routers (by default).

Router A:

```
Device(config)# clns routing
Device(config)# router isis
Device(config-router)# net 49.0001.0000.0000.000a.00
Device(config-router)# exit
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip router isis
Device(config-if)# clns router isis
Device(config)# interface gigabitethernet1/0/2
Device(config-if)# ip router isis
Device(config-if)# clns router isis
Device(config-router)# exit
```

Router B:

```
Device(config)# clns routing
Device(config)# router isis
Device(config-router)# net 49.0001.0000.0000.000b.00
Device(config-router)# exit
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip router isis
Device(config-if)# clns router isis
Device(config)# interface gigabitethernet1/0/2
Device(config-if)# ip router isis
Device(config-if)# clns router isis
Device(config-router)# exit
```

Router C:

```
Device(config)# clns routing
Device(config)# router isis
Device(config-router)# net 49.0001.0000.0000.000c.00
Device(config-router)# exit
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip router isis
Device(config-if)# clns router isis
Device(config)# interface gigabitethernet1/0/2
Device(config-if)# ip router isis
Device(config-if)# clns router isis
Device(config-router)# exit
```

## Information About Multi-VRF CE

Virtual Private Networks (VPNs) provide a secure way for customers to share bandwidth over an ISP backbone network. A VPN is a collection of sites sharing a common routing table. A customer site is connected to the service-provider network by one or more interfaces, and the service provider associates each interface with a VPN routing table, called a VPN routing/forwarding (VRF) table.

The switch supports multiple VPN routing/forwarding (multi-VRF) instances in customer edge (CE) devices (multi-VRF CE) when the it is running the IP services or advanced IP Services feature set . Multi-VRF CE allows a service provider to support two or more VPNs with overlapping IP addresses.




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**Note** The switch does not use Multiprotocol Label Switching (MPLS) to support VPNs.

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## Understanding Multi-VRF CE

Multi-VRF CE is a feature that allows a service provider to support two or more VPNs, where IP addresses can be overlapped among the VPNs. Multi-VRF CE uses input interfaces to distinguish routes for different VPNs and forms virtual packet-forwarding tables by associating one or more Layer 3 interfaces with each VRF. Interfaces in a VRF can be either physical, such as Ethernet ports, or logical, such as VLAN SVIs, but an interface cannot belong to more than one VRF at any time.




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**Note** Multi-VRF CE interfaces must be Layer 3 interfaces.

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Multi-VRF CE includes these devices:

- Customer edge (CE) devices provide customers access to the service-provider network over a data link to one or more provider edge routers. The CE device advertises the site's local routes to the router and learns the remote VPN routes from it. A switch can be a CE.
- Provider edge (PE) routers exchange routing information with CE devices by using static routing or a routing protocol such as BGP, RIPv2, OSPF, or EIGRP. The PE is only required to maintain VPN routes for those VPNs to which it is directly attached, eliminating the need for the PE to maintain all of the service-provider VPN routes. Each PE router maintains a VRF for each of its directly connected sites. Multiple interfaces on a PE router can be associated with a single VRF if all of these sites participate in

the same VPN. Each VPN is mapped to a specified VRF. After learning local VPN routes from CEs, a PE router exchanges VPN routing information with other PE routers by using internal BGP (IBPG).

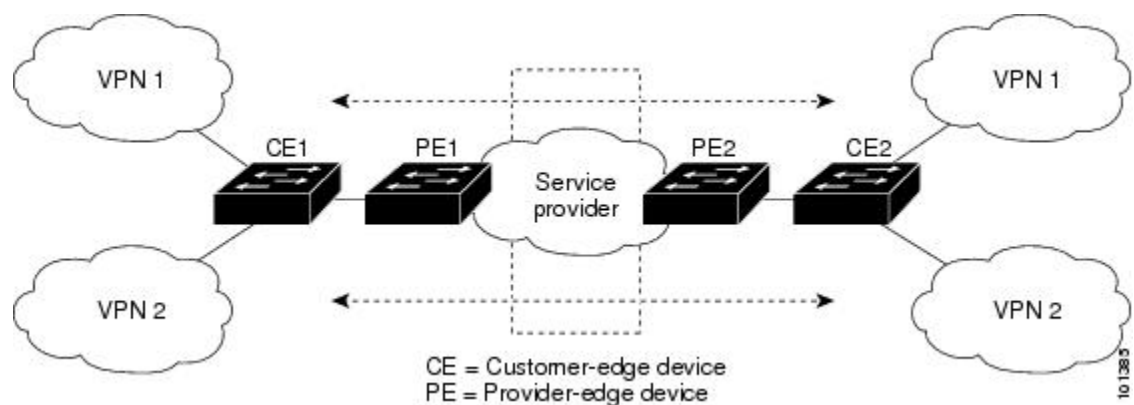
- Provider routers or core routers are any routers in the service provider network that do not attach to CE devices.

With multi-VRF CE, multiple customers can share one CE, and only one physical link is used between the CE and the PE. The shared CE maintains separate VRF tables for each customer and switches or routes packets for each customer based on its own routing table. Multi-VRF CE extends limited PE functionality to a CE device, giving it the ability to maintain separate VRF tables to extend the privacy and security of a VPN to the branch office.

## Network Topology

The figure shows a configuration using switches as multiple virtual CEs. This scenario is suited for customers who have low bandwidth requirements for their VPN service, for example, small companies. In this case, multi-VRF CE support is required in the switches. Because multi-VRF CE is a Layer 3 feature, each interface in a VRF must be a Layer 3 interface.

**Figure 103: Switches Acting as Multiple Virtual CEs**



When the CE switch receives a command to add a Layer 3 interface to a VRF, it sets up the appropriate mapping between the VLAN ID and the policy label (PL) in multi-VRF-CE-related data structures and adds the VLAN ID and PL to the VLAN database.

When multi-VRF CE is configured, the Layer 3 forwarding table is conceptually partitioned into two sections:

- The multi-VRF CE routing section contains the routes from different VPNs.
- The global routing section contains routes to non-VPN networks, such as the Internet.

VLAN IDs from different VRFs are mapped into different policy labels, which are used to distinguish the VRFs during processing. For each new VPN route learned, the Layer 3 setup function retrieves the policy label by using the VLAN ID of the ingress port and inserts the policy label and new route to the multi-VRF CE routing section. If the packet is received from a routed port, the port internal VLAN ID number is used; if the packet is received from an SVI, the VLAN number is used.

## Packet-Forwarding Process

This is the packet-forwarding process in a multi-VRF-CE-enabled network:

- When the switch receives a packet from a VPN, the switch looks up the routing table based on the input policy label number. When a route is found, the switch forwards the packet to the PE.
- When the ingress PE receives a packet from the CE, it performs a VRF lookup. When a route is found, the router adds a corresponding MPLS label to the packet and sends it to the MPLS network.
- When an egress PE receives a packet from the network, it strips the label and uses the label to identify the correct VPN routing table. Then it performs the normal route lookup. When a route is found, it forwards the packet to the correct adjacency.
- When a CE receives a packet from an egress PE, it uses the input policy label to look up the correct VPN routing table. If a route is found, it forwards the packet within the VPN.

## Network Components

To configure VRF, you create a VRF table and specify the Layer 3 interface associated with the VRF. Then configure the routing protocols in the VPN and between the CE and the PE. BGP is the preferred routing protocol used to distribute VPN routing information across the provider's backbone. The multi-VRF CE network has three major components:

- VPN route target communities—lists of all other members of a VPN community. You need to configure VPN route targets for each VPN community member.
- Multiprotocol BGP peering of VPN community PE routers—propagates VRF reachability information to all members of a VPN community. You need to configure BGP peering in all PE routers within a VPN community.
- VPN forwarding—transports all traffic between all VPN community members across a VPN service-provider network.

## VRF-Aware Services

IP services can be configured on global interfaces, and these services run within the global routing instance. IP services are enhanced to run on multiple routing instances; they are VRF-aware. Any configured VRF in the system can be specified for a VRF-aware service.

VRF-Aware services are implemented in platform-independent modules. VRF means multiple routing instances in Cisco IOS. Each platform has its own limit on the number of VRFs it supports.

VRF-aware services have the following characteristics:

- The user can ping a host in a user-specified VRF.
- ARP entries are learned in separate VRFs. The user can display Address Resolution Protocol (ARP) entries for specific VRFs.

# How to Configure Multi-VRF CE

## Default Multi-VRF CE Configuration

*Table 122: Default VRF Configuration*

<b>Feature</b>	<b>Default Setting</b>
VRF	Disabled. No VRFs are defined.
Maps	No import maps, export maps, or route maps are defined.
VRF maximum routes	Fast Ethernet switches: 8000 Gigabit Ethernet switches: 12000.
Forwarding table	The default for an interface is the global routing table.

## Multi-VRF CE Configuration Guidelines



- Note** To use multi-VRF CE, you must have the IP services or advanced IP services feature set enabled on your switch.
- A switch with multi-VRF CE is shared by multiple customers, and each customer has its own routing table.
  - Because customers use different VRF tables, the same IP addresses can be reused. Overlapped IP addresses are allowed in different VPNs.
  - Multi-VRF CE lets multiple customers share the same physical link between the PE and the CE. Trunk ports with multiple VLANs separate packets among customers. Each customer has its own VLAN.
  - Multi-VRF CE does not support all MPLS-VRF functionality. It does not support label exchange, LDP adjacency, or labeled packets.
  - For the PE router, there is no difference between using multi-VRF CE or using multiple CEs. In Figure 41-6, multiple virtual Layer 3 interfaces are connected to the multi-VRF CE device.
  - The switch supports configuring VRF by using physical ports, VLAN SVIs, or a combination of both. The SVIs can be connected through an access port or a trunk port.
  - A customer can use multiple VLANs as long as they do not overlap with those of other customers. A customer's VLANs are mapped to a specific routing table ID that is used to identify the appropriate routing tables stored on the switch.
  - The switch supports one global network and up to 32 VRFs.
  - Most routing protocols (BGP, OSPF, RIP, and static routing) can be used between the CE and the PE. However, we recommend using external BGP (EBGP) for these reasons:
    - BGP does not require multiple algorithms to communicate with multiple CEs.
    - BGP is designed for passing routing information between systems run by different administrations.
    - BGP makes it easy to pass attributes of the routes to the CE.
  - Multi-VRF CE does not affect the packet switching rate.
  - VPN multicast is not supported.
  - You can enable VRF on a private VLAN, and the reverse.
  - You cannot enable VRF when policy-based routing (PBR) is enabled on an interface, and the reverse.
  - You cannot enable VRF when Web Cache Communication Protocol (WCCP) is enabled on an interface, and the reverse.

## Configuring VRFs

Perform the following steps:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>ip routing</b> <b>Example:</b> Device(config)# ip routing	Enables IP routing.
<b>Step 3</b>	<b>ip vrf vrf-name</b> <b>Example:</b> Device(config)# ip vrf vpn1	Names the VRF, and enter VRF configuration mode.
<b>Step 4</b>	<b>rd route-distinguisher</b> <b>Example:</b> Device(config-vrf)# rd 100:2	Creates a VRF table by specifying a route distinguisher. Enter either an AS number and an arbitrary number (xxx:y) or an IP address and arbitrary number (A.B.C.D:y)
<b>Step 5</b>	<b>route-target {export   import   both}</b> <i>route-target-ext-community</i> <b>Example:</b> Device(config-vrf)# route-target both 100:2	Creates a list of import, export, or import and export route target communities for the specified VRF. Enter either an AS system number and an arbitrary number (xxx:y) or an IP address and an arbitrary number (A.B.C.D:y). The <i>route-target-ext-community</i> should be the same as the <i>route-distinguisher</i> entered in Step 4.
<b>Step 6</b>	<b>import map route-map</b> <b>Example:</b> Device(config-vrf)# import map importmap1	(Optional) Associates a route map with the VRF.
<b>Step 7</b>	<b>interface interface-id</b> <b>Example:</b> Device(config-vrf)# interface gigabitethernet 1/0/1	Specifies the Layer 3 interface to be associated with the VRF, and enter interface configuration mode. The interface can be a routed port or SVI.
<b>Step 8</b>	<b>ip vrf forwarding vrf-name</b> <b>Example:</b> Device(config-if)# ip vrf forwarding vpn1	Associates the VRF with the Layer 3 interface.  <b>Note</b> When <b>ip vrf forwarding</b> is enabled in the Management Interface, the access point does not join.

	Command or Action	Purpose
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 10</b>	<b>show ip vrf [brief   detail   interfaces]</b> <b>[vrf-name]</b> <b>Example:</b> Device# show ip vrf interfaces vpn1	Verifies the configuration. Displays information about the configured VRFs.
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Configuring VRF-Aware Services

These services are VRF-Aware:

- ARP
- Ping
- Simple Network Management Protocol (SNMP)
- Unicast Reverse Path Forwarding (uRPF)
- Syslog
- Traceroute
- FTP and TFTP




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**Note** The switch does not support VRF-aware services for Unicast Reverse Path Forwarding (uRPF) or Network Time Protocol (NTP).

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## Configuring VRF-Aware Services for ARP

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>show ip arp vrf <i>vrf-name</i></b> <b>Example:</b> Device# show ip arp vrf vpn1	Displays the ARP table in the specified VRF.

## Configuring VRF-Aware Services for Ping

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>ping vrf <i>vrf-name</i> <i>ip-host</i></b> <b>Example:</b> Device# ping vrf vpn1 ip-host	Displays the ARP table in the specified VRF.

## Configuring VRF-Aware Services for SNMP

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>snmp-server trap authentication vrf</b> <b>Example:</b> Device(config)# snmp-server trap authentication vrf	Enables SNMP traps for packets on a VRF.
<b>Step 3</b>	<b>snmp-server engineID remote <i>host vrf vpn-instance engine-id string</i></b> <b>Example:</b> Device(config)# snmp-server engineID remote 172.16.20.3 vrf vpn1 80000009030000B064EFE100	Configures a name for the remote SNMP engine on a switch.

	Command or Action	Purpose
<b>Step 4</b>	<b>snmp-server host <i>host</i> vrf <i>vpn-instance</i> traps <i>community</i></b> <b>Example:</b> <pre>Device(config)# snmp-server host 172.16.20.3 vrf vpn1 traps comaccess</pre>	Specifies the recipient of an SNMP trap operation and specifies the VRF table to be used for sending SNMP traps.
<b>Step 5</b>	<b>snmp-server host <i>host</i> vrf <i>vpn-instance</i> informs <i>community</i></b> <b>Example:</b> <pre>Device(config)# snmp-server host 172.16.20.3 vrf vpn1 informs comaccess</pre>	Specifies the recipient of an SNMP inform operation and specifies the VRF table to be used for sending SNMP informs.
<b>Step 6</b>	<b>snmp-server user <i>user group</i> remote <i>host</i> vrf <i>vpn-instance</i> security <i>model</i></b> <b>Example:</b> <pre>Device(config)# snmp-server user abcd remote 172.16.20.3 vrf vpn1 priv v2c 3des secure3des</pre>	Adds a user to an SNMP group for a remote host on a VRF for SNMP access.
<b>Step 7</b>	<b>end</b> <b>Example:</b> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.

## Configuring VRF-Aware Services for uRPF

uRPF can be configured on an interface assigned to a VRF, and source lookup is done in the VRF table.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> <pre>Device(config)# interface gigabitethernet 1/0/1</pre>	Enters interface configuration mode, and specifies the Layer 3 interface to configure.

	Command or Action	Purpose
<b>Step 3</b>	<b>no switchport</b> <b>Example:</b>  Device(config-if)# no switchport	Removes the interface from Layer 2 configuration mode if it is a physical interface.
<b>Step 4</b>	<b>ip vrf forwarding vrf-name</b> <b>Example:</b>  Device(config-if)# ip vrf forwarding vpn2	Configures VRF on the interface.
<b>Step 5</b>	<b>ip address ip-address</b> <b>Example:</b>  Device(config-if)# ip address 10.1.5.1	Enters the IP address for the interface.
<b>Step 6</b>	<b>ip verify unicast reverse-path</b> <b>Example:</b>  Device(config-if)# ip verify unicast reverse-path	Enables uRPF on the interface.
<b>Step 7</b>	<b>end</b> <b>Example:</b>  Device(config-if)# end	Returns to privileged EXEC mode.

## Configuring VRF-Aware RADIUS

To configure VRF-Aware RADIUS, you must first enable AAA on a RADIUS server. The switch supports the **ip vrf forwarding vrf-name** server-group configuration and the **ip radius source-interface** global configuration commands, as described in the Per VRF AAA Feature Guide.

## Configuring VRF-Aware Services for Syslog

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>logging on</b> <b>Example:</b>	Enables or temporarily disables logging of storage router event message.

	Command or Action	Purpose
	<code>Device(config)# logging on</code>	
<b>Step 3</b>	<b>logging host</b> <i>ip-address vrf vrf-name</i> <b>Example:</b> <code>Device(config)# logging host 10.10.1.0 vrf vpn1</code>	Specifies the host address of the syslog server where logging messages are to be sent.
<b>Step 4</b>	<b>logging buffered</b> <i>logging buffered size debugging</i> <b>Example:</b> <code>Device(config)# logging buffered critical 6000 debugging</code>	Logs messages to an internal buffer.
<b>Step 5</b>	<b>logging trap debugging</b> <b>Example:</b> <code>Device(config)# logging trap debugging</code>	Limits the logging messages sent to the syslog server.
<b>Step 6</b>	<b>logging facility</b> <i>facility</i> <b>Example:</b> <code>Device(config)# logging facility user</code>	Sends system logging messages to a logging facility.
<b>Step 7</b>	<b>end</b> <b>Example:</b> <code>Device(config-if)# end</code>	Returns to privileged EXEC mode.

## Configuring VRF-Aware Services for Traceroute

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>traceroute vrf</b> <i>vrf-name ipaddress</i> <b>Example:</b> <code>Device(config)# traceroute vrf vpn2 10.10.1.1</code>	Specifies the name of a VPN VRF in which to find the destination address.

## Configuring VRF-Aware Services for FTP and TFTP

So that FTP and TFTP are VRF-aware, you must configure some FTP/TFTP CLIs. For example, if you want to use a VRF table that is attached to an interface, say E1/0, you need to configure the `ip tftp source-interface`

E1/0 or the `ip ftp source-interface E1/0` command to inform TFTP or FTP server to use a specific routing table. In this example, the VRF table is used to look up the destination IP address. These changes are backward-compatible and do not affect existing behavior. That is, you can use the source-interface CLI to send packets out a particular interface even if no VRF is configured on that interface.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ip ftp source-interface</b> <i>interface-type</i> <i>interface-number</i> <b>Example:</b> Device(config)# <code>ip ftp source-interface</code> <code>gigabitethernet 1/0/2</code>	Specifies the source IP address for FTP connections.
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 4</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 5</b>	<b>ip tftp source-interface</b> <i>interface-type</i> <i>interface-number</i> <b>Example:</b> Device(config)# <code>ip tftp source-interface</code> <code>gigabitethernet 1/0/2</code>	Specifies the source IP address for TFTP connections.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.

## Configuring Multicast VRFs

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>ip routing</b> <b>Example:</b>  Device(config)# <b>ip routing</b>	Enables IP routing mode.
<b>Step 3</b>	<b>ip vrf vrf-name</b> <b>Example:</b>  Device(config)# <b>ip vrf vpn1</b>	Names the VRF, and enter VRF configuration mode.
<b>Step 4</b>	<b>rd route-distinguisher</b> <b>Example:</b>  Device(config-vrf)# <b>rd 100:2</b>	Creates a VRF table by specifying a route distinguisher. Enter either an AS number and an arbitrary number (xxx:y) or an IP address and an arbitrary number (A.B.C.D:y)
<b>Step 5</b>	<b>route-target {export   import   both} route-target-ext-community</b> <b>Example:</b>  Device(config-vrf)# <b>route-target import 100:2</b>	Creates a list of import, export, or import and export route target communities for the specified VRF. Enter either an AS system number and an arbitrary number (xxx:y) or an IP address and an arbitrary number (A.B.C.D:y). The <i>route-target-ext-community</i> should be the same as the <i>route-distinguisher</i> entered in Step 4.
<b>Step 6</b>	<b>import map route-map</b> <b>Example:</b>  Device(config-vrf)# <b>import map importmap1</b>	(Optional) Associates a route map with the VRF.
<b>Step 7</b>	<b>ip multicast-routing vrf vrf-name distributed</b> <b>Example:</b>  Device(config-vrf)# <b>ip multicast-routing vrf vpn1 distributed</b>	(Optional) Enables global multicast routing for VRF table.
<b>Step 8</b>	<b>interface interface-id</b> <b>Example:</b>	Specifies the Layer 3 interface to be associated with the VRF, and enter interface configuration

	Command or Action	Purpose
	Device(config-vrf)# interface gigabitethernet 1/0/2	mode. The interface can be a routed port or an SVI.
<b>Step 9</b>	<b>ip vrf forwarding vrf-name</b> <b>Example:</b>  Device(config-if)# ip vrf forwarding vpn1	Associates the VRF with the Layer 3 interface.
<b>Step 10</b>	<b>ip address ip-address mask</b> <b>Example:</b>  Device(config-if)# ip address 10.1.5.1 255.255.255.0	Configures IP address for the Layer 3 interface.
<b>Step 11</b>	<b>ip pim sparse-dense mode</b> <b>Example:</b>  Device(config-if)# ip pim sparse-dense mode	Enables PIM on the VRF-associated Layer 3 interface.
<b>Step 12</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 13</b>	<b>show ip vrf [brief   detail   interfaces]</b> <b>[vrf-name]</b> <b>Example:</b>  Device# show ip vrf detail vpn1	Verifies the configuration. Displays information about the configured VRFs.
<b>Step 14</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring a VPN Routing Session

Routing within the VPN can be configured with any supported routing protocol (RIP, OSPF, EIGRP, or BGP) or with static routing. The configuration shown here is for OSPF, but the process is the same for other protocols.



**Note** To configure an EIGRP routing process to run within a VRF instance, you must configure an autonomous-system number by entering the **autonomous-system** *autonomous-system-number* address-family configuration mode command.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>router ospf</b> <i>process-id</i> <b>vrf</b> <i>vrf-name</i> <b>Example:</b> Device(config)# router ospf 1 vrf vpn1	Enables OSPF routing, specifies a VPN forwarding table, and enter router configuration mode.
<b>Step 3</b>	<b>log-adjacency-changes</b> <b>Example:</b> Device(config-router)# log-adjacency-changes	(Optional) Logs changes in the adjacency state. This is the default state.
<b>Step 4</b>	<b>redistribute bgp</b> <i>autonomous-system-number</i> <b>subnets</b> <b>Example:</b> Device(config-router)# redistribute bgp 10 subnets	Sets the switch to redistribute information from the BGP network to the OSPF network.
<b>Step 5</b>	<b>network</b> <i>network-number</i> <b>area</b> <i>area-id</i> <b>Example:</b> Device(config-router)# network 1 area 2	Defines a network address and mask on which OSPF runs and the area ID for that network address.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config-router)# end	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show ip ospf</b> <i>process-id</i> <b>Example:</b> Device# show ip ospf 1	Verifies the configuration of the OSPF network.



	Command or Action	Purpose
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring BGP PE to CE Routing Sessions

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<b>router bgp <i>autonomous-system-number</i></b> <b>Example:</b> <pre>Device(config)# router bgp 2</pre>	Configures the BGP routing process with the AS number passed to other BGP routers, and enter router configuration mode.
<b>Step 3</b>	<b>network <i>network-number</i> mask <i>network-mask</i></b> <b>Example:</b> <pre>Device(config-router)# network 5 mask 255.255.255.0</pre>	Specifies a network and mask to announce using BGP.
<b>Step 4</b>	<b>redistribute ospf <i>process-id</i> match internal</b> <b>Example:</b> <pre>Device(config-router)# redistribute ospf 1 match internal</pre>	Sets the switch to redistribute OSPF internal routes.
<b>Step 5</b>	<b>network <i>network-number</i> area <i>area-id</i></b> <b>Example:</b> <pre>Device(config-router)# network 5 area 2</pre>	Defines a network address and mask on which OSPF runs and the area ID for that network address.
<b>Step 6</b>	<b>address-family ipv4 vrf <i>vrf-name</i></b> <b>Example:</b> <pre>Device(config-router)# address-family ipv4 vrf vpn1</pre>	Defines BGP parameters for PE to CE routing sessions, and enter VRF address-family mode.

	Command or Action	Purpose
<b>Step 7</b>	<b>neighbor address remote-as as-number</b> <b>Example:</b> <pre>Device(config-router)# neighbor 10.1.1.2 remote-as 2</pre>	Defines a BGP session between PE and CE routers.
<b>Step 8</b>	<b>neighbor address activate</b> <b>Example:</b> <pre>Device(config-router)# neighbor 10.2.1.1 activate</pre>	Activates the advertisement of the IPv4 address family.
<b>Step 9</b>	<b>end</b> <b>Example:</b> <pre>Device(config-router)# end</pre>	Returns to privileged EXEC mode.
<b>Step 10</b>	<b>show ip bgp [ipv4] [neighbors]</b> <b>Example:</b> <pre>Device# show ip bgp ipv4 neighbors</pre>	Verifies BGP configuration.
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Monitoring Multi-VRF CE

**Table 123: Commands for Displaying Multi-VRF CE Information**

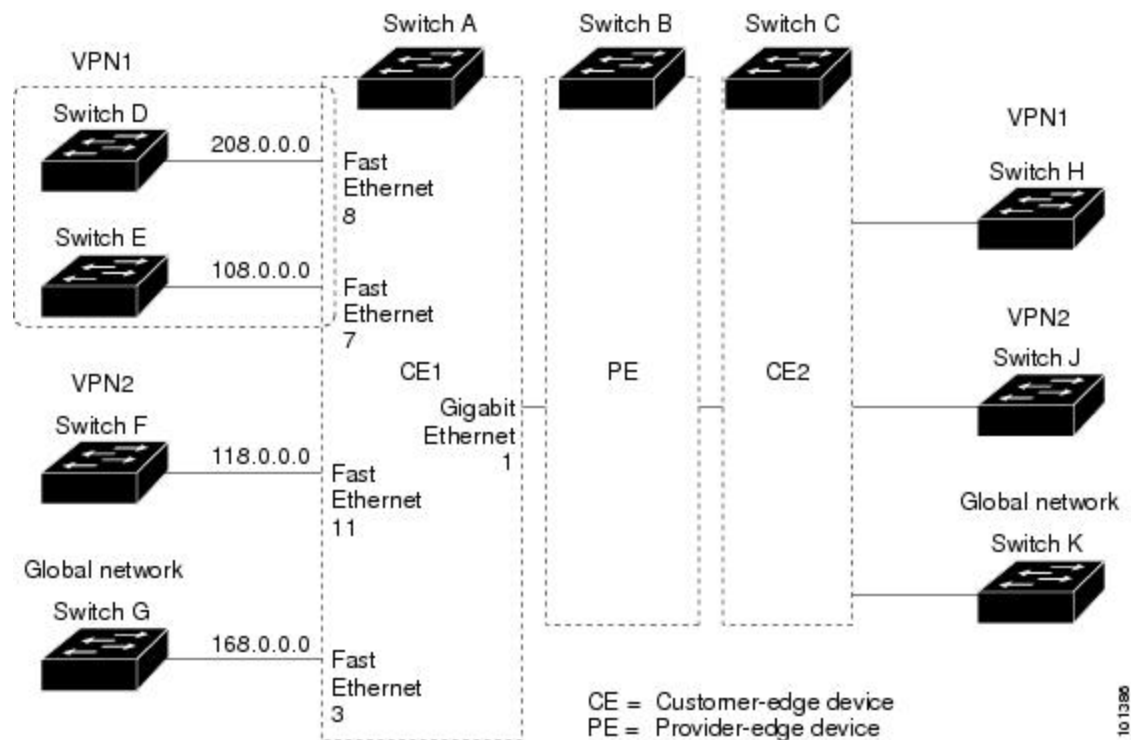
<b>show ip protocols vrf vrf-name</b>	Displays routing protocol information associated with a VRF.
<b>show ip route vrf vrf-name [connected] [protocol [as-number]] [list] [mobile] [odr] [profile] [static] [summary] [supernets-only]</b>	Displays IP routing table information associated with a VRF.
<b>show ip vrf [brief   detail   interfaces] [vrf-name]</b>	Displays information about the defined VRF instances.

# Configuration Examples for Multi-VRF CE

## Multi-VRF CE Configuration Example

OSPF is the protocol used in VPN1, VPN2, and the global network. BGP is used in the CE to PE connections. The examples following the illustration show how to configure a switch as CE Switch A, and the VRF configuration for customer switches D and F. Commands for configuring CE Switch C and the other customer switches are not included but would be similar.

Figure 104: Multi-VRF CE Configuration Example



On Switch A, enable routing and configure VRF.

```
Device# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Device(config)# ip routing
Device(config)# ip vrf v11
Device(config-vrf)# rd 800:1
Device(config-vrf)# route-target export 800:1
Device(config-vrf)# route-target import 800:1
Device(config-vrf)# exit
Device(config)# ip vrf v12
Device(config-vrf)# rd 800:2
Device(config-vrf)# route-target export 800:2
Device(config-vrf)# route-target import 800:2
Device(config-vrf)# exit
```

Configure the loopback and physical interfaces on Switch A. Gigabit Ethernet port 1 is a trunk connection to the PE. Gigabit Ethernet ports 8 and 11 connect to VPNs:

```
Device(config)# interface loopback1
Device(config-if)# ip vrf forwarding v11
Device(config-if)# ip address 8.8.1.8 255.255.255.0
Device(config-if)# exit

Device(config)# interface loopback2
Device(config-if)# ip vrf forwarding v12
Device(config-if)# ip address 8.8.2.8 255.255.255.0
Device(config-if)# exit

Device(config)# interface gigabitethernet1/0/5
Device(config-if)# switchport trunk encapsulation dot1q
Device(config-if)# switchport mode trunk
Device(config-if)# no ip address
Device(config-if)# exit
Device(config)# interface gigabitethernet1/0/8
Device(config-if)# switchport access vlan 208
Device(config-if)# no ip address
Device(config-if)# exit
Device(config)# interface gigabitethernet1/0/11
Device(config-if)# switchport trunk encapsulation dot1q
Device(config-if)# switchport mode trunk
Device(config-if)# no ip address
Device(config-if)# exit
```

Configure the VLANs used on Switch A. VLAN 10 is used by VRF 11 between the CE and the PE. VLAN 20 is used by VRF 12 between the CE and the PE. VLANs 118 and 208 are used for the VPNs that include Switch F and Switch D, respectively:

```
Device(config)# interface vlan10
Device(config-if)# ip vrf forwarding v11
Device(config-if)# ip address 38.0.0.8 255.255.255.0
Device(config-if)# exit
Device(config)# interface vlan20
Device(config-if)# ip vrf forwarding v12
Device(config-if)# ip address 83.0.0.8 255.255.255.0
Device(config-if)# exit
Device(config)# interface vlan118
Device(config-if)# ip vrf forwarding v12
Device(config-if)# ip address 118.0.0.8 255.255.255.0
Device(config-if)# exit
Device(config)# interface vlan208
Device(config-if)# ip vrf forwarding v11
Device(config-if)# ip address 208.0.0.8 255.255.255.0
Device(config-if)# exit
```

Configure OSPF routing in VPN1 and VPN2.

```
Device(config)# router ospf 1 vrf v11
Device(config-router)# redistribute bgp 800 subnets
Device(config-router)# network 208.0.0.0 0.0.0.255 area 0
Device(config-router)# exit
Device(config)# router ospf 2 vrf v12
Device(config-router)# redistribute bgp 800 subnets
Device(config-router)# network 118.0.0.0 0.0.0.255 area 0
Device(config-router)# exit
```

Configure BGP for CE to PE routing.

```
Device(config)# router bgp 800
Device(config-router)# address-family ipv4 vrf v12
Device(config-router-af)# redistribute ospf 2 match internal
Device(config-router-af)# neighbor 83.0.0.3 remote-as 100
Device(config-router-af)# neighbor 83.0.0.3 activate
Device(config-router-af)# network 8.8.2.0 mask 255.255.255.0
Device(config-router-af)# exit
Device(config-router)# address-family ipv4 vrf v11
Device(config-router-af)# redistribute ospf 1 match internal
Device(config-router-af)# neighbor 38.0.0.3 remote-as 100
Device(config-router-af)# neighbor 38.0.0.3 activate
Device(config-router-af)# network 8.8.1.0 mask 255.255.255.0
Device(config-router-af)# end
```

Switch D belongs to VPN 1. Configure the connection to Switch A by using these commands.

```
Device# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Device(config)# ip routing
Device(config)# interface gigabitethernet1/0/2
Device(config-if)# no switchport
Device(config-if)# ip address 208.0.0.20 255.255.255.0
Device(config-if)# exit

Device(config)# router ospf 101
Device(config-router)# network 208.0.0.0 0.0.0.255 area 0
Device(config-router)# end
```

Switch F belongs to VPN 2. Configure the connection to Switch A by using these commands.

```
Device# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Device(config)# ip routing
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# switchport trunk encapsulation dot1q
Device(config-if)# switchport mode trunk
Device(config-if)# no ip address
Device(config-if)# exit

Device(config)# interface vlan118
Device(config-if)# ip address 118.0.0.11 255.255.255.0
Device(config-if)# exit

Device(config)# router ospf 101
Device(config-router)# network 118.0.0.0 0.0.0.255 area 0
Device(config-router)# end
```

When used on switch B (the PE router), these commands configure only the connections to the CE device, Switch A.

```
Router# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# ip vrf v1
Router(config-vrf)# rd 100:1
Router(config-vrf)# route-target export 100:1
Router(config-vrf)# route-target import 100:1
Router(config-vrf)# exit

Router(config)# ip vrf v2
Router(config-vrf)# rd 100:2
Router(config-vrf)# route-target export 100:2
Router(config-vrf)# route-target import 100:2
```

```

Router(config-vrf)# exit
Router(config)# ip cef
Router(config)# interface Loopback1
Router(config-if)# ip vrf forwarding v1
Router(config-if)# ip address 3.3.1.3 255.255.255.0
Router(config-if)# exit

Router(config)# interface Loopback2
Router(config-if)# ip vrf forwarding v2
Router(config-if)# ip address 3.3.2.3 255.255.255.0
Router(config-if)# exit

Router(config)# interface gigabitethernet1/1/0.10
Router(config-if)# encapsulation dot1q 10
Router(config-if)# ip vrf forwarding v1
Router(config-if)# ip address 38.0.0.3 255.255.255.0
Router(config-if)# exit

Router(config)# interface gigabitethernet1/1/0.20
Router(config-if)# encapsulation dot1q 20
Router(config-if)# ip vrf forwarding v2
Router(config-if)# ip address 83.0.0.3 255.255.255.0
Router(config-if)# exit

Router(config)# router bgp 100
Router(config-router)# address-family ipv4 vrf v2
Router(config-router-af)# neighbor 83.0.0.8 remote-as 800
Router(config-router-af)# neighbor 83.0.0.8 activate
Router(config-router-af)# network 3.3.2.0 mask 255.255.255.0
Router(config-router-af)# exit
Router(config-router)# address-family ipv4 vrf v1
Router(config-router-af)# neighbor 38.0.0.8 remote-as 800
Router(config-router-af)# neighbor 38.0.0.8 activate
Router(config-router-af)# network 3.3.1.0 mask 255.255.255.0
Router(config-router-af)# end

```

## Configuring Unicast Reverse Path Forwarding

The unicast reverse path forwarding (unicast RPF) feature helps to mitigate problems that are caused by the introduction of malformed or forged (spoofed) IP source addresses into a network by discarding IP packets that lack a verifiable IP source address. For example, a number of common types of denial-of-service (DoS) attacks, including Smurf and Tribal Flood Network (TFN), can take advantage of forged or rapidly changing source IP addresses to allow attackers to thwart efforts to locate or filter the attacks. For Internet service providers (ISPs) that provide public access, Unicast RPF deflects such attacks by forwarding only packets that have source addresses that are valid and consistent with the IP routing table. This action protects the network of the ISP, its customer, and the rest of the Internet.



### Note

- Unicast RPF is supported in IP Services .
- Do not configure unicast RPF if the switch is in a mixed hardware stack combining more than one switch type. For example, Catalyst 3750-X, Catalyst 3750-E, and Catalyst 3750 switches.

# Protocol-Independent Features

This section describes IP routing protocol-independent features that are available on switches running the IP Base or the IP Services feature set ;except that with the IP Base feature set, protocol-related features are available only for RIP.

## Distributed Cisco Express Forwarding

### Information About Cisco Express Forwarding

Cisco Express Forwarding (CEF) is a Layer 3 IP switching technology used to optimize network performance. CEF implements an advanced IP look-up and forwarding algorithm to deliver maximum Layer 3 switching performance. CEF is less CPU-intensive than fast switching route caching, allowing more CPU processing power to be dedicated to packet forwarding. In a switch stack, the hardware uses distributed CEF (dCEF) in the stack. In dynamic networks, fast switching cache entries are frequently invalidated because of routing changes, which can cause traffic to be process switched using the routing table, instead of fast switched using the route cache. CEF and dCEF use the Forwarding Information Base (FIB) lookup table to perform destination-based switching of IP packets.

The two main components in CEF and dCEF are the distributed FIB and the distributed adjacency tables.

- The FIB is similar to a routing table or information base and maintains a mirror image of the forwarding information in the IP routing table. When routing or topology changes occur in the network, the IP routing table is updated, and those changes are reflected in the FIB. The FIB maintains next-hop address information based on the information in the IP routing table. Because the FIB contains all known routes that exist in the routing table, CEF eliminates route cache maintenance, is more efficient for switching traffic, and is not affected by traffic patterns.
- Nodes in the network are said to be adjacent if they can reach each other with a single hop across a link layer. CEF uses adjacency tables to prepend Layer 2 addressing information. The adjacency table maintains Layer 2 next-hop addresses for all FIB entries.

Because the switch or switch stack uses Application Specific Integrated Circuits (ASICs) to achieve Gigabit-speed line rate IP traffic, CEF or dCEF forwarding applies only to the software-forwarding path, that is, traffic that is forwarded by the CPU.

### How to Configure Cisco Express Forwarding

CEF or distributed CEF is enabled globally by default. If for some reason it is disabled, you can re-enable it by using the **ip cef** or **ip cef distributed** global configuration command.

The default configuration is CEF or dCEF enabled on all Layer 3 interfaces. Entering the **no ip route-cache cef** interface configuration command disables CEF for traffic that is being forwarded by software. This command does not affect the hardware forwarding path. Disabling CEF and using the **debug ip packet detail** privileged EXEC command can be useful to debug software-forwarded traffic. To enable CEF on an interface for the software-forwarding path, use the **ip route-cache cef** interface configuration command.

**Caution**

Although the **no ip route-cache cef** interface configuration command to disable CEF on an interface is visible in the CLI, we strongly recommend that you do not disable CEF or dCEF on interfaces except for debugging purposes.

To enable CEF or dCEF globally and on an interface for software-forwarded traffic if it has been disabled:

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>ip cef</b> <b>Example:</b>  Device(config)# ip cef	Enables CEF operation on a non-stacking switch.  Go to Step 4.
<b>Step 3</b>	<b>ip cef distributed</b> <b>Example:</b>  Device(config)# ip cef distributed	Enables CEF operation on a active switch.
<b>Step 4</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device(config)# interface gigabitethernet 1/0/1	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
<b>Step 5</b>	<b>ip route-cache cef</b> <b>Example:</b>  Device(config-if)# ip route-cache cef	Enables CEF on the interface for software-forwarded traffic.
<b>Step 6</b>	<b>end</b> <b>Example:</b>  Device(config-if)# end	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show ip cef</b> <b>Example:</b>  Device# show ip cef	Displays the CEF status on all interfaces.



	Command or Action	Purpose
<b>Step 8</b>	<b>show cef linecard [detail]</b> <b>Example:</b> <pre>Device# show cef linecard detail</pre>	(Optional) Displays CEF-related interface information on a non-stacking switch.
<b>Step 9</b>	<b>show cef linecard [slot-number] [detail]</b> <b>Example:</b> <pre>Device# show cef linecard 5 detail</pre>	(Optional) Displays CEF-related interface information on a switch by stack member for all switches in the stack or for the specified switch.  (Optional) For <i>slot-number</i> , enter the stack member switch number.
<b>Step 10</b>	<b>show cef interface [interface-id]</b> <b>Example:</b> <pre>Device# show cef interface gigabitethernet 1/0/1</pre>	Displays detailed CEF information for all interfaces or the specified interface.
<b>Step 11</b>	<b>show adjacency</b> <b>Example:</b> <pre>Device# show adjacency</pre>	Displays CEF adjacency table information.
<b>Step 12</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Load-Balancing Scheme for CEF Traffic

### Restrictions for Cisco Express Forwarding Load-Balancing

You must globally configure load balancing on device or device stack members in the same way: either in per-destination or per-packet mode. It is not possible to configure some packet prefixes in per-destination mode and others in per-packet mode.

### Prerequisites for Configuring a Load-Balancing Scheme for CEF Traffic

If you enable per-packet load balancing for traffic going to a particular destination, all interfaces that can forward traffic to that destination must be enabled for per-packet load balancing.

### CEF Load-Balancing Overview

CEF load balancing allows you to optimize resources by distributing traffic over multiple paths. CEF load balancing works based on a combination of source and destination packet information.

You can configure load balancing on a per-destination or per-packet basis. Because load-balancing decisions are made on the outbound interface, load balancing must be configured on the outbound interface.

## Per-Destination Load Balancing for CEF Traffic

Per-destination load balancing allows the device to use multiple paths to achieve load sharing across multiple source-destination host pairs. Packets for a given source-destination host pair are guaranteed to take the same path, even if multiple paths are available. Traffic streams destined for different pairs tend to take different paths.

Per-destination load balancing is enabled by default when you enable CEF. To use per-destination load balancing, you do not perform any additional tasks once CEF is enabled. Per-destination is the load-balancing method of choice for most situations.

Because per-destination load balancing depends on the statistical distribution of traffic, load sharing becomes more effective as the number of source-destination host pairs increases.

You can use per-destination load balancing to ensure that packets for a given host pair arrive in order. All packets intended for a certain host pair are routed over the same link (or links).

Typically, you disable per-destination load balancing when you want to enable per-packet load balancing.

## Per-Packet Load Balancing for CEF Traffic

Per-packet load balancing allows the device to send successive data packets over different paths without regard to individual hosts or user sessions. It uses the round-robin method to determine which path each packet takes to the destination. Per-packet load balancing ensures that the traffic is balanced over multiple links.

Per-packet load balancing is good for single-path destinations, but packets for a given source-destination host pair might take different paths. Per-packet load balancing can therefore introduce reordering of packets. This type of load balancing is inappropriate for certain types of data traffic (such as voice traffic over IP) that depend on packets arriving at the destination in sequence.

Use per-packet load balancing to help ensure that a path for a single source-destination host pair does not get overloaded. If the bulk of the data passing through parallel links is for a single pair, per-destination load balancing overloads a single link while other links have very little traffic. Enabling per-packet load balancing allows you to use alternate paths to the same busy destination.

## Load-Balancing Algorithms for CEF Traffic

The following load-balancing algorithms are provided for use with CEF traffic. You select a load-balancing algorithm with the **ip cef load-sharing algorithm** command.

- Original algorithm—The original load-balancing algorithm produces distortions in load sharing across multiple devices because the same algorithm was used on every device. Depending on your network environment, you should select the algorithm.
- Universal algorithm—The universal load-balancing algorithm allows each device on the network to make a different load sharing decision for each source-destination address pair, which resolves load-sharing imbalances. The device is set to perform universal load sharing by default.

## How to Configure a Load-Balancing for CEF Traffic

The following sections provide information on configuring load-balancing for CEF traffic.

## Enabling or Disabling CEF Per-Destination Load Balancing

To enable per-packet load balancing, per-destination load balancing needs to be disabled.

To enable or disable CEF per-destination load balancing, perform the following procedure:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device# <b>enable</b>	Enters global configuration mode.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config-if)# interface gigabitethernet 1/0/1	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
<b>Step 4</b>	<b>[no] ip cef load-sharing [per-packet] [per-destination]</b> <b>Example:</b> Device(config-if)# no ip cef load-sharing per-destination	Enables load balancing for CEF. <ul style="list-style-type: none"> <li>• The <b>no ip cef load-sharing</b> command disables CEF load balancing.</li> <li>• The <b>per-packet</b> keyword enables per-packet load balancing on the interface.</li> <li>• The <b>per-destination</b> keyword enables per-destination load balancing on the interface.</li> </ul>
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-if)# end	Returns to privileged EXEC mode.

## Configuring CEF Per-Packet Load Balancing

To configure CEF per-packet load balancing, perform the following procedure:

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device# <b>enable</b>	Enters global configuration mode.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device(config-if)# <b>interface</b> <b>gigabitethernet 1/0/1</b>	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
<b>Step 4</b>	<b>[no] ip load-sharing [per-packet] [per-destination]</b> <b>Example:</b>  Device(config-if)# <b>ip load-sharing</b> <b>per-packet</b>	Enables load balancing for CEF. <ul style="list-style-type: none"> <li>• The <b>per-packet</b> keyword enables per-packet load balancing on the interface.</li> <li>• The <b>per-destination</b> keyword enables per-destination load balancing on the interface.</li> </ul>
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

**Selecting a Tunnel Load-Balancing Algorithm for CEF Traffic**

Select the tunnel algorithm when your network environment contains only a few source and destination pairs. The device is set to perform universal load sharing by default.

To select a tunnel load-balancing algorithm for CEF traffic, perform the following procedure:

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device# <b>enable</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>ip cef load-sharing algorithm {original   universal [id]}</b> <b>Example:</b> Device(config)# <code>ip cef load-sharing algorithm universal</code>	Selects a CEF load-balancing algorithm. <ul style="list-style-type: none"> <li>• The <b>original</b> keyword sets the load-balancing algorithm to the original algorithm, based on a source and destination hash.</li> <li>• The <b>universal</b> keyword sets the load-balancing algorithm to one that uses a source and destination and an ID hash.</li> <li>• The <i>id</i> argument is a fixed identifier.</li> </ul>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.

## Configuration Examples for CEF Traffic Load-Balancing

The following sections provide configuration examples for CEF traffic load-balancing.

### Example: Enabling or Disabling CEF Per-Destination Load Balancing

Per-destination load balancing is enabled by default when you enable CEF. Typically, you disable per-destination load balancing when you want to enable per-packet load balancing. The following example shows how to disable per-destination load balancing:

```
Device> enable
Device# configure terminal
Device(config)# interface Ethernet1/0/1
Device(config-if)# no ip load-sharing per-destination
Device(config-if)# end
```

### Example: Configuring CEF Per-Packet Load Balancing

The following example shows how to configure per-packet load balancing for CEF:

```
Device> enable
Device# configure terminal
Device(config)# interface Ethernet1/0/1
Device(config-if)# ip load-sharing per-packet
Device(config-if)# end
```

# Number of Equal-Cost Routing Paths

## Information About Equal-Cost Routing Paths

When a router has two or more routes to the same network with the same metrics, these routes can be thought of as having an equal cost. The term parallel path is another way to see occurrences of equal-cost routes in a routing table. If a router has two or more equal-cost paths to a network, it can use them concurrently. Parallel paths provide redundancy in case of a circuit failure and also enable a router to load balance packets over the available paths for more efficient use of available bandwidth. Equal-cost routes are supported across switches in a stack.

Even though the router automatically learns about and configures equal-cost routes, you can control the maximum number of parallel paths supported by an IP routing protocol in its routing table. Although the switch software allows a maximum of 32 equal-cost routes, the switch hardware will never use more than 16 paths per route.

## How to Configure Equal-Cost Routing Paths

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>router {bgp   rip   ospf   eigrp}</b> <b>Example:</b>  Device(config)# router eigrp	Enters router configuration mode.
<b>Step 3</b>	<b>maximum-paths maximum</b> <b>Example:</b>  Device(config-router)# maximum-paths 2	Sets the maximum number of parallel paths for the protocol routing table. The range is from 1 to 16; the default is 4 for most IP routing protocols, but only 1 for BGP.
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device(config-router)# end	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show ip protocols</b> <b>Example:</b>  Device# show ip protocols	Verifies the setting in the <i>Maximum path</i> field.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Device# copy running-config startup-config	

## Static Unicast Routes

### Information About Static Unicast Routes

Static unicast routes are user-defined routes that cause packets moving between a source and a destination to take a specified path. Static routes can be important if the router cannot build a route to a particular destination and are useful for specifying a gateway of last resort to which all unroutable packets are sent.

The switch retains static routes until you remove them. However, you can override static routes with dynamic routing information by assigning administrative distance values. Each dynamic routing protocol has a default administrative distance, as listed in Table 41-16. If you want a static route to be overridden by information from a dynamic routing protocol, set the administrative distance of the static route higher than that of the dynamic protocol.

**Table 124: Dynamic Routing Protocol Default Administrative Distances**

Route Source	Default Distance
Connected interface	0
Static route	1
Enhanced IRGP summary route	5
External BGP	20
Internal Enhanced IGRP	90
IGRP	100
OSPF	110
Internal BGP	200
Unknown	225

Static routes that point to an interface are advertised through RIP, IGRP, and other dynamic routing protocols, whether or not static **redistribute** router configuration commands were specified for those routing protocols. These static routes are advertised because static routes that point to an interface are considered in the routing table to be connected and hence lose their static nature. However, if you define a static route to an interface that is not one of the networks defined in a network command, no dynamic routing protocols advertise the route unless a **redistribute** static command is specified for these protocols.

When an interface goes down, all static routes through that interface are removed from the IP routing table. When the software can no longer find a valid next hop for the address specified as the forwarding router's address in a static route, the static route is also removed from the IP routing table.

## Configuring Static Unicast Routes

Static unicast routes are user-defined routes that cause packets moving between a source and a destination to take a specified path. Static routes can be important if the router cannot build a route to a particular destination and are useful for specifying a gateway of last resort to which all unroutable packets are sent.

Follow these steps to configure a static route:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip route prefix mask {address   interface} [distance]</b> <b>Example:</b> Device(config)# <b>ip route prefix mask gigabitethernet 1/0/4</b>	Establish a static route.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show ip route</b> <b>Example:</b> Device# <b>show ip route</b>	Displays the current state of the routing table to verify the configuration.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.



**What to do next**

Use the **no ip route** *prefix mask {address| interface}* global configuration command to remove a static route. The device retains static routes until you remove them.

## Default Routes and Networks

### Information About Default Routes and Networks

A router might not be able to learn the routes to all other networks. To provide complete routing capability, you can use some routers as smart routers and give the remaining routers default routes to the smart router. (Smart routers have routing table information for the entire internetwork.) These default routes can be dynamically learned or can be configured in the individual routers. Most dynamic interior routing protocols include a mechanism for causing a smart router to generate dynamic default information that is then forwarded to other routers.

If a router has a directly connected interface to the specified default network, the dynamic routing protocols running on that device generate a default route. In RIP, it advertises the pseudonetwork 0.0.0.0.

A router that is generating the default for a network also might need a default of its own. One way a router can generate its own default is to specify a static route to the network 0.0.0.0 through the appropriate device.

When default information is passed through a dynamic routing protocol, no further configuration is required. The system periodically scans its routing table to choose the optimal default network as its default route. In IGRP networks, there might be several candidate networks for the system default. Cisco routers use administrative distance and metric information to set the default route or the gateway of last resort.

If dynamic default information is not being passed to the system, candidates for the default route are specified with the **ip default-network** global configuration command. If this network appears in the routing table from any source, it is flagged as a possible choice for the default route. If the router has no interface on the default network, but does have a path to it, the network is considered as a possible candidate, and the gateway to the best default path becomes the gateway of last resort.

### How to Configure Default Routes and Networks

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>ip default-network network number</b> <b>Example:</b>  Device(config)# ip default-network 1	Specifies a default network.
<b>Step 3</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	<code>Device(config)# end</code>	
<b>Step 4</b>	<b>show ip route</b> <b>Example:</b> <code>Device# show ip route</code>	Displays the selected default route in the gateway of last resort display.
<b>Step 5</b>	<b>copy running-config startup-config</b> <b>Example:</b> <code>Device# copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Route Maps to Redistribute Routing Information

### Information About Route Maps

The switch can run multiple routing protocols simultaneously, and it can redistribute information from one routing protocol to another. Redistributing information from one routing protocol to another applies to all supported IP-based routing protocols.

You can also conditionally control the redistribution of routes between routing domains by defining enhanced packet filters or route maps between the two domains. The **match** and **set** route-map configuration commands define the condition portion of a route map. The **match** command specifies that a criterion must be matched. The **set** command specifies an action to be taken if the routing update meets the conditions defined by the match command. Although redistribution is a protocol-independent feature, some of the **match** and **set** route-map configuration commands are specific to a particular protocol.

One or more **match** commands and one or more **set** commands follow a **route-map** command. If there are no **match** commands, everything matches. If there are no **set** commands, nothing is done, other than the match. Therefore, you need at least one **match** or **set** command.



**Note** A route map with no **set** route-map configuration commands is sent to the CPU, which causes high CPU utilization.

You can also identify route-map statements as **permit** or **deny**. If the statement is marked as a deny, the packets meeting the match criteria are sent back through the normal forwarding channels (destination-based routing). If the statement is marked as permit, set clauses are applied to packets meeting the match criteria. Packets that do not meet the match criteria are forwarded through the normal routing channel.

### How to Configure a Route Map

Although each of Steps 3 through 14 in the following section is optional, you must enter at least one **match** route-map configuration command and one **set** route-map configuration command.



**Note** The keywords are the same as defined in the procedure to control the route distribution.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>route-map</b> <i>map-tag</i> [ <b>permit</b>   <b>deny</b> ] [ <i>sequence number</i> ] <b>Example:</b> Device(config)# route-map rip-to-ospf permit 4	Defines any route maps used to control redistribution and enter route-map configuration mode.  <i>map-tag</i> —A meaningful name for the route map. The <b>redistribute</b> router configuration command uses this name to reference this route map. Multiple route maps might share the same map tag name.  (Optional) If <b>permit</b> is specified and the match criteria are met for this route map, the route is redistributed as controlled by the set actions. If <b>deny</b> is specified, the route is not redistributed.  <i>sequence number</i> (Optional)— Number that indicates the position a new route map is to have in the list of route maps already configured with the same name.
<b>Step 3</b>	<b>match as-path</b> <i>path-list-number</i> <b>Example:</b> Device(config-route-map)#match as-path 10	Matches a BGP AS path access list.
<b>Step 4</b>	<b>match community-list</b> <i>community-list-number</i> [ <b>exact</b> ] <b>Example:</b> Device(config-route-map)# match community-list 150	Matches a BGP community list.
<b>Step 5</b>	<b>match ip address</b> { <i>access-list-number</i>   <i>access-list-name</i> } [... <i>access-list-number</i>   ... <i>access-list-name</i> ] <b>Example:</b>	Matches a standard access list by specifying the name or number. It can be an integer from 1 to 199.

	Command or Action	Purpose
	Device(config-route-map)# match ip address 5 80	
<b>Step 6</b>	<b>match metric</b> <i>metric-value</i> <b>Example:</b> Device(config-route-map)# match metric 2000	Matches the specified route metric. The <i>metric-value</i> can be an EIGRP metric with a specified value from 0 to 4294967295.
<b>Step 7</b>	<b>match ip next-hop</b> { <i>access-list-number</i>   <i>access-list-name</i> } [... <i>access-list-number</i>   ... <i>access-list-name</i> ] <b>Example:</b> Device(config-route-map)# match ip next-hop 8 45	Matches a next-hop router address passed by one of the access lists specified (numbered from 1 to 199).
<b>Step 8</b>	<b>match tag</b> <i>tag value</i> [... <i>tag-value</i> ] <b>Example:</b> Device(config-route-map)# match tag 3500	Matches the specified tag value in a list of one or more route tag values. Each can be an integer from 0 to 4294967295.
<b>Step 9</b>	<b>match interface</b> <i>type number</i> [... <i>type-number</i> ] <b>Example:</b> Device(config-route-map)# match interface gigabitethernet 1/0/1	Matches the specified next hop route out one of the specified interfaces.
<b>Step 10</b>	<b>match ip route-source</b> { <i>access-list-number</i>   <i>access-list-name</i> } [... <i>access-list-number</i>   ... <i>access-list-name</i> ] <b>Example:</b> Device(config-route-map)# match ip route-source 10 30	Matches the address specified by the specified advertised access lists.
<b>Step 11</b>	<b>match route-type</b> { <i>local</i>   <i>internal</i>   <i>external</i> [ <i>type-1</i>   <i>type-2</i> ]} <b>Example:</b> Device(config-route-map)# match route-type local	Matches the specified <b>route-type</b> : <ul style="list-style-type: none"> <li>• <b>local</b>—Locally generated BGP routes.</li> <li>• <b>internal</b>—OSPF intra-area and interarea routes or EIGRP internal routes.</li> <li>• <b>external</b>—OSPF external routes (Type 1 or Type 2) or EIGRP external routes.</li> </ul>
<b>Step 12</b>	<b>set dampening</b> <i>half-life reuse suppress max-suppress-time</i> <b>Example:</b>	Sets BGP route dampening factors.

	Command or Action	Purpose
	Device(config-route-map)# set dampening 30 1500 10000 120	
<b>Step 13</b>	<b>set local-preference <i>value</i></b> <b>Example:</b>  Device(config-route-map)# set local-preference 100	Assigns a value to a local BGP path.
<b>Step 14</b>	<b>set origin {igp   egp <i>as</i>   incomplete}</b> <b>Example:</b>  Device(config-route-map)#set origin igp	Sets the BGP origin code.
<b>Step 15</b>	<b>set as-path {tag   prepend <i>as-path-string</i>}</b> <b>Example:</b>  Device(config-route-map)# set as-path tag	Modifies the BGP autonomous system path.
<b>Step 16</b>	<b>set level {level-1   level-2   level-1-2   stub-area   backbone}</b> <b>Example:</b>  Device(config-route-map)# set level level-1-2	Sets the level for routes that are advertised into the specified area of the routing domain. The <b>stub-area</b> and <b>backbone</b> are OSPF NSSA and backbone areas.
<b>Step 17</b>	<b>set metric <i>metric value</i></b> <b>Example:</b>  Device(config-route-map)# set metric 100	Sets the metric value to give the redistributed routes (for EIGRP only). The <i>metric value</i> is an integer from -294967295 to 294967295.
<b>Step 18</b>	<b>set metricbandwidth delay reliability loading <i>mtu</i></b> <b>Example:</b>  Device(config-route-map)# set metric 10000 10 255 1 1500	Sets the metric value to give the redistributed routes (for EIGRP only): <ul style="list-style-type: none"> <li><i>bandwidth</i>—Metric value or IGRP bandwidth of the route in kilobits per second in the range 0 to 4294967295</li> <li><i>delay</i>—Route delay in tens of microseconds in the range 0 to 4294967295.</li> <li><i>reliability</i>—Likelihood of successful packet transmission expressed as a number between 0 and 255, where 255 means 100 percent reliability and 0 means no reliability.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <i>loading</i>—Effective bandwidth of the route expressed as a number from 0 to 255 (255 is 100 percent loading).</li> <li>• <i>mtu</i>—Minimum maximum transmission unit (MTU) size of the route in bytes in the range 0 to 4294967295.</li> </ul>
<b>Step 19</b>	<b>set metric-type {type-1   type-2}</b> <b>Example:</b> <pre>Device(config-route-map)# set metric-type type-2</pre>	Sets the OSPF external metric type for redistributed routes.
<b>Step 20</b>	<b>set metric-type internal</b> <b>Example:</b> <pre>Device(config-route-map)# set metric-type internal</pre>	Sets the multi-exit discriminator (MED) value on prefixes advertised to external BGP neighbor to match the IGP metric of the next hop.
<b>Step 21</b>	<b>set weight number</b> <b>Example:</b> <pre>Device(config-route-map)# set weight 100</pre>	Sets the BGP weight for the routing table. The value can be from 1 to 65535.
<b>Step 22</b>	<b>end</b> <b>Example:</b> <pre>Device(config-route-map)# end</pre>	Returns to privileged EXEC mode.
<b>Step 23</b>	<b>show route-map</b> <b>Example:</b> <pre>Device# show route-map</pre>	Displays all route maps configured or only the one specified to verify configuration.
<b>Step 24</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## How to Control Route Distribution

Although each of Steps 3 through 14 in the following section is optional, you must enter at least one **match** route-map configuration command and one **set** route-map configuration command.



**Note** The keywords are the same as defined in the procedure to configure the route map for redistribution.

The metrics of one routing protocol do not necessarily translate into the metrics of another. For example, the RIP metric is a hop count, and the IGRP metric is a combination of five qualities. In these situations, an artificial metric is assigned to the redistributed route. Uncontrolled exchanging of routing information between different routing protocols can create routing loops and seriously degrade network operation.

If you have not defined a default redistribution metric that replaces metric conversion, some automatic metric translations occur between routing protocols:

- RIP can automatically redistribute static routes. It assigns static routes a metric of 1 (directly connected).
- Any protocol can redistribute other routing protocols if a default mode is in effect.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>router { rip   ospf   eigrp }</b> <b>Example:</b>  Device(config)# router eigrp 10	Enters router configuration mode.
<b>Step 3</b>	<b>redistribute protocol [process-id] {level-1   level-1-2   level-2} [metric metric-value] [metric-type type-value] [match internal   external type-value] [tag tag-value] [route-map map-tag] [weight weight] [subnets]</b> <b>Example:</b>  Device(config-router)# redistribute eigrp 1	Redistributes routes from one routing protocol to another routing protocol. If no route-maps are specified, all routes are redistributed. If the keyword <b>route-map</b> is specified with no <i>map-tag</i> , no routes are distributed.
<b>Step 4</b>	<b>default-metric number</b> <b>Example:</b>  Device(config-router)# default-metric 1024	Cause the current routing protocol to use the same metric value for all redistributed routes (RIP and OSPF).
<b>Step 5</b>	<b>default-metric bandwidth delay reliability loading mtu</b> <b>Example:</b>	Cause the EIGRP routing protocol to use the same metric value for all non-EIGRP redistributed routes.

	Command or Action	Purpose
	Device(config-router)# default-metric 1000 100 250 100 1500	
<b>Step 6</b>	<b>end</b>  <b>Example:</b>  Device(config-router)# end	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show route-map</b>  <b>Example:</b>  Device# show route-map	Displays all route maps configured or only the one specified to verify configuration.
<b>Step 8</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Policy-Based Routing

### Information About Policy-Based Routing

You can use policy-based routing (PBR) to configure a defined policy for traffic flows. By using PBR, you can have more control over routing by reducing the reliance on routes derived from routing protocols. PBR can specify and implement routing policies that allow or deny paths based on:

- Identity of a particular end system
- Application
- Protocol

You can use PBR to provide equal-access and source-sensitive routing, routing based on interactive versus batch traffic, or routing based on dedicated links. For example, you could transfer stock records to a corporate office on a high-bandwidth, high-cost link for a short time while transmitting routine application data such as e-mail over a low-bandwidth, low-cost link.

With PBR, you classify traffic using access control lists (ACLs) and then make traffic go through a different path. PBR is applied to incoming packets. All packets received on an interface with PBR enabled are passed through route maps. Based on the criteria defined in the route maps, packets are forwarded (routed) to the appropriate next hop.

- Route map statement marked as permit is processed as follows:
  - A match command can match on length or multiple ACLs. A route map statement can contain multiple match commands. Logical or algorithm function is performed across all the match commands to reach a permit or deny decision.

For example:



```
match length A B
match ip address acl1 acl2
match ip address acl3
```

A packet is permitted if it is permitted by match length A B or acl1 or acl2 or acl3

- If the decision reached is permit, then the action specified by the set command is applied on the packet .
- If the decision reached is deny, then the PBR action (specified in the set command) is not applied. Instead the processing logic moves forward to look at the next route-map statement in the sequence (the statement with the next higher sequence number). If no next statement exists, PBR processing terminates, and the packet is routed using the default IP routing table.
- For PBR, route-map statements marked as deny are not supported.

You can use standard IP ACLs to specify match criteria for a source address or extended IP ACLs to specify match criteria based on an application, a protocol type, or an end station. The process proceeds through the route map until a match is found. If no match is found, normal destination-based routing occurs. There is an implicit deny at the end of the list of match statements.

If match clauses are satisfied, you can use a set clause to specify the IP addresses identifying the next hop router in the path.

## How to Configure PBR

- To use PBR, you must have the IP Base feature set enabled on the switch or stack master.
- Multicast traffic is not policy-routed. PBR applies only to unicast traffic.
- You can enable PBR on a routed port or an SVI.
- The switch supports PBR based on match length.
- You can apply a policy route map to an EtherChannel port channel in Layer 3 mode, but you cannot apply a policy route map to a physical interface that is a member of the EtherChannel. If you try to do so, the command is rejected. When a policy route map is applied to a physical interface, that interface cannot become a member of an EtherChannel.
- You can define a maximum of 128 IP policy route maps on the switch or switch stack.
- You can define a maximum of 512 access control entries (ACEs) for PBR on the switch or switch stack.
- When configuring match criteria in a route map, follow these guidelines:
  - Do not match ACLs that permit packets destined for a local address.
- VRF and PBR are mutually exclusive on a switch interface. You cannot enable VRF when PBR is enabled on an interface. The reverse is also true, you cannot enable PBR when VRF is enabled on an interface.
- Web Cache Communication Protocol (WCCP) and PBR are mutually exclusive on a switch interface. You cannot enable WCCP when PBR is enabled on an interface. The reverse is also true, you cannot enable PBR when WCCP is enabled on an interface.
- The number of hardware entries used by PBR depends on the route map itself, the ACLs used, and the order of the ACLs and route-map entries.

- PBR based on TOS, DSCP and IP Precedence are not supported.
- Set interface, set default next-hop and set default interface are not supported.
- **ip next-hop recursive** and **ip next-hop verify availability** features are not available and the next-hop should be directly connected.
- Policy-maps with no set actions are supported. Matching packets are routed normally.
- Policy-maps with no match clauses are supported. Set actions are applied to all packets.

By default, PBR is disabled on the switch. To enable PBR, you must create a route map that specifies the match criteria and the resulting action. Then, you must enable PBR for that route map on an interface. All packets arriving on the specified interface matching the match clauses are subject to PBR.

Packets that are generated by the switch, or local packets, are not normally policy-routed. When you globally enable local PBR on the switch, all packets that originate on the switch are subject to local PBR. Local PBR is disabled by default.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>route-map map-tag [permit] [sequence number]</b> <b>Example:</b> Device(config)# route-map pbr-map permit	Defines route maps that are used to control where packets are output, and enters route-map configuration mode. <ul style="list-style-type: none"> <li>• <i>map-tag</i> – A meaningful name for the route map. The <b>ip policy route-map</b> interface configuration command uses this name to reference the route map. Multiple route-map statements with the same map tag define a single route map.</li> <li>• (Optional) <b>permit</b> – If <b>permit</b> is specified and the match criteria are met for this route map, the route is policy routed as defined by the set actions.</li> <li>• (Optional) <i>sequence number</i> – The sequence number shows the position of the route-map statement in the given route map.</li> </ul>
<b>Step 3</b>	<b>match ip address {access-list-number   access-list-name} [access-list-number  ...access-list-name]</b> <b>Example:</b> Device(config-route-map)# match ip address 110 140	Matches the source and destination IP addresses that are permitted by one or more standard or extended access lists. ACLs can match on more than one source and destination IP address.

	Command or Action	Purpose
		If you do not specify a <b>match</b> command, the route map is applicable to all packets.
<b>Step 4</b>	<b>match length min max</b> <b>Example:</b> <pre>Device(config-route-map)# match length 64 1500</pre>	Matches the length of the packet.
<b>Step 5</b>	<b>set ip next-hop ip-address [...ip-address]</b> <b>Example:</b> <pre>Device(config-route-map)# set ip next-hop 10.1.6.2</pre>	Specifies the action to be taken on the packets that match the criteria. Sets next hop to which to route the packet (the next hop must be adjacent).
<b>Step 6</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-route-map)# exit</pre>	Returns to global configuration mode.
<b>Step 7</b>	<b>interface interface-id</b> <b>Example:</b> <pre>Device(config)# interface gigabitethernet 1/0/1</pre>	Enters interface configuration mode, and specifies the interface to be configured.
<b>Step 8</b>	<b>ip policy route-map map-tag</b> <b>Example:</b> <pre>Device(config-if)# ip policy route-map pbr-map</pre>	Enables PBR on a Layer 3 interface, and identify the route map to use. You can configure only one route map on an interface. However, you can have multiple route map entries with different sequence numbers. These entries are evaluated in the order of sequence number until the first match. If there is no match, packets are routed as usual.
<b>Step 9</b>	<b>ip route-cache policy</b> <b>Example:</b> <pre>Device(config-if)# ip route-cache policy</pre>	(Optional) Enables fast-switching PBR. You must enable PBR before enabling fast-switching PBR.
<b>Step 10</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-if)# exit</pre>	Returns to global configuration mode.
<b>Step 11</b>	<b>ip local policy route-map map-tag</b> <b>Example:</b> <pre>Device(config)# ip local policy route-map local-pbr</pre>	(Optional) Enables local PBR to perform policy-based routing on packets originating at the switch. This applies to packets generated by the switch, and not to incoming packets.
<b>Step 12</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 13</b>	<b>show route-map</b> [ <i>map-name</i> ] <b>Example:</b> Device# show route-map	(Optional) Displays all the route maps configured or only the one specified to verify configuration.
<b>Step 14</b>	<b>show ip policy</b> <b>Example:</b> Device# show ip policy	(Optional) Displays policy route maps attached to the interface.
<b>Step 15</b>	<b>show ip local policy</b> <b>Example:</b> Device# show ip local policy	(Optional) Displays whether or not local policy routing is enabled and, if so, the route map being used.

## Filtering Routing Information

You can filter routing protocol information by performing the tasks described in this section.



**Note** When routes are redistributed between OSPF processes, no OSPF metrics are preserved.

## Setting Passive Interfaces

To prevent other routers on a local network from dynamically learning about routes, you can use the **passive-interface** router configuration command to keep routing update messages from being sent through a router interface. When you use this command in the OSPF protocol, the interface address you specify as passive appears as a stub network in the OSPF domain. OSPF routing information is neither sent nor received through the specified router interface.

In networks with many interfaces, to avoid having to manually set them as passive, you can set all interfaces to be passive by default by using the **passive-interface default** router configuration command and manually setting interfaces where adjacencies are desired.

Use a network monitoring privileged EXEC command such as **show ip ospf interface** to verify the interfaces that you enabled as passive, or use the **show ip interface** privileged EXEC command to verify the interfaces that you enabled as active.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>router { rip   ospf   eigrp }</b> <b>Example:</b>	Enters router configuration mode.

	Command or Action	Purpose
	<code>Device(config)# router ospf</code>	
<b>Step 3</b>	<b>passive-interface</b> <i>interface-id</i> <b>Example:</b> <code>Device(config-router)# passive-interface gigabitethernet 1/0/1</code>	Suppresses sending routing updates through the specified Layer 3 interface.
<b>Step 4</b>	<b>passive-interface default</b> <b>Example:</b> <code>Device(config-router)# passive-interface default</code>	(Optional) Sets all interfaces as passive by default.
<b>Step 5</b>	<b>no passive-interface</b> <i>interface type</i> <b>Example:</b> <code>Device(config-router)# no passive-interface gigabitethernet1/0/3 gigabitethernet 1/0/5</code>	(Optional) Activates only those interfaces that need to have adjacencies sent.
<b>Step 6</b>	<b>network</b> <i>network-address</i> <b>Example:</b> <code>Device(config-router)# network 10.1.1.1</code>	(Optional) Specifies the list of networks for the routing process. The <i>network-address</i> is an IP address.
<b>Step 7</b>	<b>end</b> <b>Example:</b> <code>Device(config-router)# end</code>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> <code>Device# copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Controlling Advertising and Processing in Routing Updates

You can use the **distribute-list** router configuration command with access control lists to suppress routes from being advertised in routing updates and to prevent other routers from learning one or more routes. When used in OSPF, this feature applies to only external routes, and you cannot specify an interface name.

You can also use a **distribute-list** router configuration command to avoid processing certain routes listed in incoming updates. (This feature does not apply to OSPF.)

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>router { rip   eigrp }</b> <b>Example:</b>  Device(config)# router eigrp 10	Enters router configuration mode.
<b>Step 3</b>	<b>distribute-list {access-list-number   access-list-name} out [interface-name   routing process   autonomous-system-number]</b> <b>Example:</b>  Device(config-router)# distribute 120 out gigabitethernet 1/0/7	Permits or denies routes from being advertised in routing updates, depending upon the action listed in the access list.
<b>Step 4</b>	<b>distribute-list {access-list-number   access-list-name} in [type-number]</b> <b>Example:</b>  Device(config-router)# distribute-list 125 in	Suppresses processing in routes listed in updates.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config-router)# end	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

**Filtering Sources of Routing Information**

Because some routing information might be more accurate than others, you can use filtering to prioritize information coming from different sources. An administrative distance is a rating of the trustworthiness of a routing information source, such as a router or group of routers. In a large network, some routing protocols can be more reliable than others. By specifying administrative distance values, you enable the router to intelligently discriminate between sources of routing information. The router always picks the route whose routing protocol has the lowest administrative distance.

Because each network has its own requirements, there are no general guidelines for assigning administrative distances.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>router { rip   ospf   eigrp }</b> <b>Example:</b>  Device(config)# router eigrp 10	Enters router configuration mode.
<b>Step 3</b>	<b>distance weight {ip-address {ip-address mask}} [ip access list]</b> <b>Example:</b>  Device(config-router)# distance 50 10.1.1.5.1	Defines an administrative distance.  <i>weight</i> —The administrative distance as an integer from 10 to 255. Used alone, <i>weight</i> specifies a default administrative distance that is used when no other specification exists for a routing information source. Routes with a distance of 255 are not installed in the routing table.  (Optional) <i>ip access list</i> —An IP standard or extended access list to be applied to incoming routing updates.
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device(config-router)# end	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show ip protocols</b> <b>Example:</b>  Device# show ip protocols	Displays the default administrative distance for a specified routing process.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Managing Authentication Keys

Key management is a method of controlling authentication keys used by routing protocols. Not all protocols can use key management. Authentication keys are available for EIGRP and RIP Version 2.

## Prerequisites

Before you manage authentication keys, you must enable authentication. See the appropriate protocol section to see how to enable authentication for that protocol. To manage authentication keys, define a key chain, identify the keys that belong to the key chain, and specify how long each key is valid. Each key has its own key identifier (specified with the **key number** key chain configuration command), which is stored locally. The combination of the key identifier and the interface associated with the message uniquely identifies the authentication algorithm and Message Digest 5 (MD5) authentication key in use.

## How to Configure Authentication Keys

You can configure multiple keys with life times. Only one authentication packet is sent, regardless of how many valid keys exist. The software examines the key numbers in order from lowest to highest, and uses the first valid key it encounters. The lifetimes allow for overlap during key changes. Note that the router must know these lifetimes.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>key chain <i>name-of-chain</i></b> <b>Example:</b> Device(config)# key chain key10	Identifies a key chain, and enter key chain configuration mode.
<b>Step 3</b>	<b>key <i>number</i></b> <b>Example:</b> Device(config-keychain)# key 2000	Identifies the key number. The range is 0 to 2147483647.
<b>Step 4</b>	<b>key-string <i>text</i></b> <b>Example:</b> Device(config-keychain)# Room 20, 10th floor	Identifies the key string. The string can contain from 1 to 80 uppercase and lowercase alphanumeric characters, but the first character cannot be a number.
<b>Step 5</b>	<b>accept-lifetime <i>start-time</i> {infinite   <i>end-time</i>   <i>duration seconds</i>}</b> <b>Example:</b> Device(config-keychain)# accept-lifetime 12:30:00 Jan 25 1009 infinite	(Optional) Specifies the time period during which the key can be received.  The <i>start-time</i> and <i>end-time</i> syntax can be either <i>hh:mm:ss Month date year</i> or <i>hh:mm:ss date Month year</i> . The default is forever with the default <i>start-time</i> and the earliest acceptable date as January 1, 1993. The default <i>end-time</i> and <b>duration</b> is <b>infinite</b> .



	Command or Action	Purpose
<b>Step 6</b>	<b>send-lifetime</b> <i>start-time</i> { <b>infinite</b>   <i>end-time</i>   <b>duration</b> <i>seconds</i> }  <b>Example:</b>  <pre>Device(config-keychain)# accept-lifetime 23:30:00 Jan 25 1019 infinite</pre>	(Optional) Specifies the time period during which the key can be sent.  The <i>start-time</i> and <i>end-time</i> syntax can be either <i>hh:mm:ss Month date year</i> or <i>hh:mm:ss date Month year</i> . The default is forever with the default <i>start-time</i> and the earliest acceptable date as January 1, 1993. The default <i>end-time</i> and <b>duration</b> is <b>infinite</b> .
<b>Step 7</b>	<b>end</b>  <b>Example:</b>  <pre>Device(config-keychain)# end</pre>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show key chain</b>  <b>Example:</b>  <pre>Device# show key chain</pre>	Displays authentication key information.
<b>Step 9</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Monitoring and Maintaining the IP Network

You can remove all contents of a particular cache, table, or database. You can also display specific statistics.

**Table 125: Commands to Clear IP Routes or Display Route Status**

Command	Purpose
<b>clear ip route</b> { <i>network</i> [ <i>mask</i>   *]}	Clears one or more routes from the IP routing table.
<b>show ip protocols</b>	Displays the parameters and state of the active routing protocol process.
<b>show ip route</b> [ <i>address</i> [ <i>mask</i> ] [ <b>longer-prefixes</b> ]]   [ <i>protocol</i> [ <i>process-id</i> ]]	Displays the current state of the routing table.
<b>show ip route summary</b>	Displays the current state of the routing table in summary form.
<b>show ip route supernets-only</b>	Displays supernets.
<b>show ip cache</b>	Displays the routing table used to switch IP traffic.

Command	Purpose
<code>show route-map</code> [ <i>map-name</i> ]	Displays all route maps configured or only the one specified.



# PART **XVII**

## **Security**

- [Preventing Unauthorized Access](#) , on page 1711
- [Controlling Switch Access with Passwords and Privilege Levels](#) , on page 1713
- [Configuring TACACS+](#) , on page 1729
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## CHAPTER 94

# Preventing Unauthorized Access

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- [Finding Feature Information, on page 1711](#)
- [Preventing Unauthorized Access, on page 1711](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Preventing Unauthorized Access

You can prevent unauthorized users from reconfiguring your switch and viewing configuration information. Typically, you want network administrators to have access to your switch while you restrict access to users who dial from outside the network through an asynchronous port, connect from outside the network through a serial port, or connect through a terminal or workstation from within the local network.

To prevent unauthorized access into your switch, you should configure one or more of these security features:

- At a minimum, you should configure passwords and privileges at each switch port. These passwords are locally stored on the switch. When users attempt to access the switch through a port or line, they must enter the password specified for the port or line before they can access the switch.
- For an additional layer of security, you can also configure username and password pairs, which are locally stored on the switch. These pairs are assigned to lines or ports and authenticate each user before that user can access the switch. If you have defined privilege levels, you can also assign a specific privilege level (with associated rights and privileges) to each username and password pair.
- If you want to use username and password pairs, but you want to store them centrally on a server instead of locally, you can store them in a database on a security server. Multiple networking devices can then use the same database to obtain user authentication (and, if necessary, authorization) information.

- You can also enable the login enhancements feature, which logs both failed and unsuccessful login attempts. Login enhancements can also be configured to block future login attempts after a set number of unsuccessful attempts are made. For more information, see the Cisco IOS Login Enhancements documentation.

**Related Topics**

[Configuring Username and Password Pairs](#), on page 1722

[TACACS+ and Switch Access](#), on page 1731

[Setting a Telnet Password for a Terminal Line](#), on page 1720



## CHAPTER 95

# Controlling Switch Access with Passwords and Privilege Levels

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- [Finding Feature Information, on page 1713](#)
- [Restrictions for Controlling Switch Access with Passwords and Privileges, on page 1713](#)
- [Information About Passwords and Privilege Levels, on page 1714](#)
- [How to Control Switch Access with Passwords and Privilege Levels, on page 1716](#)
- [Monitoring Switch Access, on page 1726](#)
- [Configuration Examples for Setting Passwords and Privilege Levels, on page 1727](#)
- [Additional References, on page 1728](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Restrictions for Controlling Switch Access with Passwords and Privileges

The following are the restrictions for controlling switch access with passwords and privileges:

- Disabling password recovery will not work if you have set the switch to boot up manually by using the **boot manual** global configuration command. This command produces the boot loader prompt (*switch:*) after the switch is power cycled.

### Related Topics

- [Disabling Password Recovery, on page 1719](#)
- [Password Recovery, on page 1714](#)

# Information About Passwords and Privilege Levels

## Default Password and Privilege Level Configuration

A simple way of providing terminal access control in your network is to use passwords and assign privilege levels. Password protection restricts access to a network or network device. Privilege levels define what commands users can enter after they have logged into a network device.

This table shows the default password and privilege level configuration.

**Table 126: Default Password and Privilege Levels**

Feature	Default Setting
Enable password and privilege level	No password is defined. The default is level 15 (privileged EXEC level). The password is not encrypted in the configuration file.
Enable secret password and privilege level	No password is defined. The default is level 15 (privileged EXEC level). The password is encrypted before it is written to the configuration file.
Line password	No password is defined.

## Additional Password Security

To provide an additional layer of security, particularly for passwords that cross the network or that are stored on a Trivial File Transfer Protocol (TFTP) server, you can use either the **enable password** or **enable secret** global configuration commands. Both commands accomplish the same thing; that is, you can establish an encrypted password that users must enter to access privileged EXEC mode (the default) or any privilege level you specify.

We recommend that you use the **enable secret** command because it uses an improved encryption algorithm.

If you configure the **enable secret** command, it takes precedence over the **enable password** command; the two commands cannot be in effect simultaneously.

If you enable password encryption, it applies to all passwords including username passwords, authentication key passwords, the privileged command password, and console and virtual terminal line passwords.

### Related Topics

[Protecting Enable and Enable Secret Passwords with Encryption](#), on page 1717

[Example: Protecting Enable and Enable Secret Passwords with Encryption](#), on page 1727

## Password Recovery

By default, any end user with physical access to the switch can recover from a lost password by interrupting the boot process while the switch is powering on and then by entering a new password.

The password-recovery disable feature protects access to the switch password by disabling part of this functionality. When this feature is enabled, the end user can interrupt the boot process only by agreeing to set



the system back to the default configuration. With password recovery disabled, you can still interrupt the boot process and change the password, but the configuration file (config.text) and the VLAN database file (vlan.dat) are deleted.

If you disable password recovery, we recommend that you keep a backup copy of the configuration file on a secure server in case the end user interrupts the boot process and sets the system back to default values. Do not keep a backup copy of the configuration file on the switch. If the switch is operating in VTP transparent mode, we recommend that you also keep a backup copy of the VLAN database file on a secure server. When the switch is returned to the default system configuration, you can download the saved files to the switch by using the Xmodem protocol.

To re-enable password recovery, use the **service password-recovery** global configuration command.

#### Related Topics

[Disabling Password Recovery](#), on page 1719

[Restrictions for Controlling Switch Access with Passwords and Privileges](#), on page 1713

## Terminal Line Telnet Configuration

When you power-up your switch for the first time, an automatic setup program runs to assign IP information and to create a default configuration for continued use. The setup program also prompts you to configure your switch for Telnet access through a password. If you did not configure this password during the setup program, you can configure it when you set a Telnet password for a terminal line.

#### Related Topics

[Setting a Telnet Password for a Terminal Line](#), on page 1720

[Example: Setting a Telnet Password for a Terminal Line](#), on page 1727

## Username and Password Pairs

You can configure username and password pairs, which are locally stored on the switch. These pairs are assigned to lines or ports and authenticate each user before that user can access the switch. If you have defined privilege levels, you can also assign a specific privilege level (with associated rights and privileges) to each username and password pair.

#### Related Topics

[Configuring Username and Password Pairs](#), on page 1722

## Privilege Levels

Cisco devices use privilege levels to provide password security for different levels of switch operation. By default, the Cisco IOS software operates in two modes (privilege levels) of password security: user EXEC (Level 1) and privileged EXEC (Level 15). You can configure up to 16 hierarchical levels of commands for each mode. By configuring multiple passwords, you can allow different sets of users to have access to specified commands.

#### Privilege Levels on Lines

Users can override the privilege level you set using the **privilege level** line configuration command by logging in to the line and enabling a different privilege level. They can lower the privilege level by using the **disable** command. If users know the password to a higher privilege level, they can use that password to enable the

higher privilege level. You might specify a high level or privilege level for your console line to restrict line usage.

For example, if you want many users to have access to the **clear line** command, you can assign it level 2 security and distribute the level 2 password fairly widely. But if you want more restricted access to the **configure** command, you can assign it level 3 security and distribute that password to a more restricted group of users.

### Command Privilege Levels

When you set a command to a privilege level, all commands whose syntax is a subset of that command are also set to that level. For example, if you set the **show ip traffic** command to level 15, the **show** commands and **show ip** commands are automatically set to privilege level 15 unless you set them individually to different levels.

### Related Topics

[Setting the Privilege Level for a Command](#), on page 1723

[Example: Setting the Privilege Level for a Command](#), on page 1727

[Changing the Default Privilege Level for Lines](#), on page 1725

[Logging into and Exiting a Privilege Level](#), on page 1726

# How to Control Switch Access with Passwords and Privilege Levels

## Setting or Changing a Static Enable Password

The enable password controls access to the privileged EXEC mode. Follow these steps to set or change a static enable password:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>enable password</b> <i>password</i> <b>Example:</b> Device (config) # <b>enable password secret321</b>	Defines a new password or changes an existing password for access to privileged EXEC mode. By default, no password is defined.

	Command or Action	Purpose
		<p>For <i>password</i>, specify a string from 1 to 25 alphanumeric characters. The string cannot start with a number, is case sensitive, and allows spaces but ignores leading spaces. It can contain the question mark (?) character if you precede the question mark with the key combination Ctrl-v when you create the password; for example, to create the password abc?123, do this:</p> <ol style="list-style-type: none"> <li>a. Enter <b>abc</b>.</li> <li>b. Enter <b>Ctrl-v</b>.</li> <li>c. Enter <b>?123</b>.</li> </ol> <p>When the system prompts you to enter the enable password, you need not precede the question mark with the Ctrl-v; you can simply enter abc?123 at the password prompt.</p>
<b>Step 4</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 5</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 6</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Example: Setting or Changing a Static Enable Password](#), on page 1727

## Protecting Enable and Enable Secret Passwords with Encryption

Follow these steps to establish an encrypted password that users must enter to access privileged EXEC mode (the default) or any privilege level you specify:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <code>enable password [level level] {password encryption-type encrypted-password}</code></li> <li>• <code>enable secret [level level] {password encryption-type encrypted-password}</code></li> </ul> <b>Example:</b> Device(config)# <b>enable password example102</b> or Device(config)# <b>enable secret level 1 password secret123sample</b>	<ul style="list-style-type: none"> <li>• Defines a new password or changes an existing password for access to privileged EXEC mode.</li> <li>• Defines a secret password, which is saved using a nonreversible encryption method.               <ul style="list-style-type: none"> <li>• (Optional) For <i>level</i>, the range is from 0 to 15. Level 1 is normal user EXEC mode privileges. The default level is 15 (privileged EXEC mode privileges).</li> <li>• For <i>password</i>, specify a string from 1 to 25 alphanumeric characters. The string cannot start with a number, is case sensitive, and allows spaces but ignores leading spaces. By default, no password is defined.</li> <li>• (Optional) For <i>encryption-type</i>, only type 5, a Cisco proprietary encryption algorithm, is available. If you specify an encryption type, you must provide an encrypted password—an encrypted password that you copy from another switch configuration.</li> </ul> </li> </ul> <p><b>Note</b> If you specify an encryption type and then enter a clear text password, you can not re-enter privileged EXEC mode. You cannot recover a lost encrypted password by any method.</p>

	Command or Action	Purpose
<b>Step 4</b>	<b>service password-encryption</b> <b>Example:</b> <pre>Device(config)# service password-encryption</pre>	(Optional) Encrypts the password when the password is defined or when the configuration is written.  Encryption prevents the password from being readable in the configuration file.
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Additional Password Security](#), on page 1714

[Example: Protecting Enable and Enable Secret Passwords with Encryption](#), on page 1727

## Disabling Password Recovery

Follow these steps to disable password recovery to protect the security of your switch:

**Before you begin**

If you disable password recovery, we recommend that you keep a backup copy of the configuration file on a secure server in case the end user interrupts the boot process and sets the system back to default values. Do not keep a backup copy of the configuration file on the switch. If the switch is operating in VTP transparent mode, we recommend that you also keep a backup copy of the VLAN database file on a secure server. When the switch is returned to the default system configuration, you can download the saved files to the switch by using the Xmodem protocol.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>	Enables privileged EXEC mode.

	Command or Action	Purpose
	<b>Example:</b>  Device> <b>enable</b>	<ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>system disable password recovery switch</b> { <i>all</i>   < <i>1-9</i> >}  <b>Example:</b>  Device(config)# <b>system disable password recovery switch all</b>	Disables password recovery. <ul style="list-style-type: none"> <li>• <i>all</i> - Sets the configuration on switches in stack.</li> <li>• &lt;<i>1-9</i>&gt; - Sets the configuration on the Switch Number selected.</li> </ul> This setting is saved in an area of the flash memory that is accessible by the boot loader and the Cisco IOS image, but it is not part of the file system and is not accessible by any user.
<b>Step 4</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.

### What to do next

To remove **disable password recovery**, use the **no system disable password recovery switch all** global configuration command.

### Related Topics

[Password Recovery](#), on page 1714

[Restrictions for Controlling Switch Access with Passwords and Privileges](#), on page 1713

## Setting a Telnet Password for a Terminal Line

Beginning in user EXEC mode, follow these steps to set a Telnet password for the connected terminal line:

### Before you begin

- Attach a PC or workstation with emulation software to the switch console port, or attach a PC to the Ethernet management port.
- The default data characteristics of the console port are 9600, 8, 1, no parity. You might need to press the Return key several times to see the command-line prompt.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	<b>Note</b> If a password is required for access to privileged EXEC mode, you will be prompted for it.  Enters privileged EXEC mode.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>line vty 0 15</b> <b>Example:</b> <pre>Device(config)# line vty 0 15</pre>	Configures the number of Telnet sessions (lines), and enters line configuration mode.  There are 16 possible sessions on a command-capable Device. The 0 and 15 mean that you are configuring all 16 possible Telnet sessions.
<b>Step 4</b>	<b>password <i>password</i></b> <b>Example:</b> <pre>Device(config-line)# password abcxyz543</pre>	Sets a Telnet password for the line or lines.  For <i>password</i> , specify a string from 1 to 25 alphanumeric characters. The string cannot start with a number, is case sensitive, and allows spaces but ignores leading spaces. By default, no password is defined.
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config-line)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Related Topics

[Information about Passwords and Privilege Levels](#)

[Preventing Unauthorized Access](#), on page 1711

[Terminal Line Telnet Configuration](#), on page 1715

[Example: Setting a Telnet Password for a Terminal Line](#), on page 1727

## Configuring Username and Password Pairs

Follow these steps to configure username and password pairs:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>username name [privilege level] {password encryption-type password}</b> <b>Example:</b> Device(config)# <b>username adamsample privilege 1 password secret456</b> Device(config)# <b>username 111111111111 mac attribute</b>	Sets the username, privilege level, and password for each user. <ul style="list-style-type: none"> <li>• For <i>name</i>, specify the user ID as one word or the MAC address. Spaces and quotation marks are not allowed.</li> <li>• You can configure a maximum of 12000 clients each, for both username and MAC filter.</li> <li>• (Optional) For <i>level</i>, specify the privilege level the user has after gaining access. The range is 0 to 15. Level 15 gives privileged EXEC mode access. Level 1 gives user EXEC mode access.</li> <li>• For <i>encryption-type</i>, enter 0 to specify that an unencrypted password will follow. Enter 7 to specify that a hidden password will follow.</li> <li>• For <i>password</i>, specify the password the user must enter to gain access to the Device. The password must be from 1 to 25 characters, can contain embedded spaces, and must be the last option specified in the <b>username</b> command.</li> </ul>



	Command or Action	Purpose
<b>Step 4</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>line console 0</b></li> <li>• <b>line vty 0 15</b></li> </ul> <b>Example:</b> Device(config)# <b>line console 0</b>  or Device(config)# <b>line vty 15</b>	Enters line configuration mode, and configures the console port (line 0) or the VTY lines (line 0 to 15).
<b>Step 5</b>	<b>login local</b> <b>Example:</b> Device(config-line)# <b>login local</b>	Enables local password checking at login time. Authentication is based on the username specified in Step 3.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Information about Passwords and Privilege Levels](#)

[Preventing Unauthorized Access](#), on page 1711

[Username and Password Pairs](#), on page 1715

## Setting the Privilege Level for a Command

Follow these steps to set the privilege level for a command:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>privilege mode level level command</b> <b>Example:</b> Device(config)# <b>privilege exec level 14 configure</b>	Sets the privilege level for a command. <ul style="list-style-type: none"> <li>• For <i>mode</i>, enter <b>configure</b> for global configuration mode, <b>exec</b> for EXEC mode, <b>interface</b> for interface configuration mode, or <b>line</b> for line configuration mode.</li> <li>• For <i>level</i>, the range is from 0 to 15. Level 1 is for normal user EXEC mode privileges. Level 15 is the level of access permitted by the <b>enable</b> password.</li> <li>• For <i>command</i>, specify the command to which you want to restrict access.</li> </ul>
<b>Step 4</b>	<b>enable password level level password</b> <b>Example:</b> Device(config)# <b>enable password level 14 SecretPswd14</b>	Specifies the password to enable the privilege level. <ul style="list-style-type: none"> <li>• For <i>level</i>, the range is from 0 to 15. Level 1 is for normal user EXEC mode privileges.</li> <li>• For <i>password</i>, specify a string from 1 to 25 alphanumeric characters. The string cannot start with a number, is case sensitive, and allows spaces but ignores leading spaces. By default, no password is defined.</li> </ul>
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Device# <code>copy running-config startup-config</code>	

### Related Topics

[Privilege Levels](#), on page 1715

[Example: Setting the Privilege Level for a Command](#), on page 1727

## Changing the Default Privilege Level for Lines

Follow these steps to change the default privilege level for the specified line:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>line vty line</b> <b>Example:</b> Device(config)# <code>line vty 10</code>	Selects the virtual terminal line on which to restrict access.
<b>Step 4</b>	<b>privilege level level</b> <b>Example:</b> Device(config)# <code>privilege level 15</code>	Changes the default privilege level for the line. For <i>level</i> , the range is from 0 to 15. Level 1 is for normal user EXEC mode privileges. Level 15 is the level of access permitted by the <b>enable</b> password.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Device# <code>copy running-config startup-config</code>	

### What to do next

Users can override the privilege level you set using the **privilege level** line configuration command by logging in to the line and enabling a different privilege level. They can lower the privilege level by using the **disable** command. If users know the password to a higher privilege level, they can use that password to enable the higher privilege level. You might specify a high level or privilege level for your console line to restrict line usage.

### Related Topics

[Privilege Levels](#), on page 1715

## Logging into and Exiting a Privilege Level

Beginning in user EXEC mode, follow these steps to log into a specified privilege level and exit a specified privilege level.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <i>level</i> <b>Example:</b> Device> <code>enable 15</code>	Logs in to a specified privilege level. Following the example, Level 15 is privileged EXEC mode. For <i>level</i> , the range is 0 to 15.
<b>Step 2</b>	<b>disable</b> <i>level</i> <b>Example:</b> Device# <code>disable 1</code>	Exits to a specified privilege level. Following the example, Level 1 is user EXEC mode. For <i>level</i> , the range is 0 to 15.

### Related Topics

[Privilege Levels](#), on page 1715

## Monitoring Switch Access

Table 127: Commands for Displaying DHCP Information

<code>show privilege</code>	Displays the privilege level configuration.
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# Configuration Examples for Setting Passwords and Privilege Levels

## Example: Setting or Changing a Static Enable Password

This example shows how to change the enable password to *11u2c3k4y5*. The password is not encrypted and provides access to level 15 (traditional privileged EXEC mode access):

```
Device(config)# enable password 11u2c3k4y5
```

### Related Topics

[Setting or Changing a Static Enable Password](#), on page 1716

## Example: Protecting Enable and Enable Secret Passwords with Encryption

This example shows how to configure the encrypted password *\$1\$FaD0\$Xyti5Rkls3LoyxzS8* for privilege level 2:

```
Device(config)# enable secret level 2 5 $1$FaD0$Xyti5Rkls3LoyxzS8
```

### Related Topics

[Protecting Enable and Enable Secret Passwords with Encryption](#), on page 1717  
[Additional Password Security](#), on page 1714

## Example: Setting a Telnet Password for a Terminal Line

This example shows how to set the Telnet password to *let45me67in89*:

```
Device(config)# line vty 10  
Device(config-line)# password let45me67in89
```

### Related Topics

[Setting a Telnet Password for a Terminal Line](#), on page 1720  
[Terminal Line Telnet Configuration](#), on page 1715

## Example: Setting the Privilege Level for a Command

This example shows how to set the **configure** command to privilege level 14 and define *SecretPswd14* as the password users must enter to use level 14 commands:

```
Device(config)# privilege exec level 14 configure  
Device(config)# enable password level 14 SecretPswd14
```

**Related Topics**

[Setting the Privilege Level for a Command](#), on page 1723

[Privilege Levels](#), on page 1715

# Additional References

**Error Message Decoder**

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**MIBs**

MB	MIBs Link
	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>



## CHAPTER 96

# Configuring TACACS+

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- [Finding Feature Information, on page 1729](#)
- [Prerequisites for TACACS+, on page 1729](#)
- [Information About TACACS+, on page 1731](#)
- [How to Configure Switch Access with TACACS+, on page 1735](#)
- [Monitoring TACACS+, on page 1742](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for TACACS+

The following are the prerequisites for set up and configuration of switch access with TACACS+ (must be performed in the order presented):

1. Configure the switches with the TACACS+ server addresses.
2. Set an authentication key.
3. Configure the key from Step 2 on the TACACS+ servers.
4. Enable authentication, authorization, and accounting (AAA).
5. Create a login authentication method list.
6. Apply the list to the terminal lines.
7. Create an authorization and accounting method list.

The following are the prerequisites for controlling switch access with TACACS+:

- You must have access to a configured TACACS+ server to configure TACACS+ features on your switch. Also, you must have access to TACACS+ services maintained in a database on a TACACS+ daemon typically running on a LINUX or Windows workstation.
- We recommend a redundant connection between a switch stack and the TACACS+ server. This is to help ensure that the TACACS+ server remains accessible in case one of the connected stack members is removed from the switch stack.
- You need a system running the TACACS+ daemon software to use TACACS+ on your switch.
- To use TACACS+, it must be enabled.
- Authorization must be enabled on the switch to be used.
- Users must first successfully complete TACACS+ authentication before proceeding to TACACS+ authorization.
- To use any of the AAA commands listed in this section or elsewhere, you must first enable AAA with the **aaa new-model** command.
- At a minimum, you must identify the host or hosts maintaining the TACACS+ daemon and define the method lists for TACACS+ authentication. You can optionally define method lists for TACACS+ authorization and accounting.
- The method list defines the types of authentication to be performed and the sequence in which they are performed; it must be applied to a specific port before any of the defined authentication methods are performed. The only exception is the default method list (which, by coincidence, is named *default*). The default method list is automatically applied to all ports except those that have a named method list explicitly defined. A defined method list overrides the default method list.
- Use TACACS+ for privileged EXEC access authorization if authentication was performed by using TACACS+.
- Use the local database if authentication was not performed by using TACACS+.

### Related Topics

[TACACS+ Overview](#), on page 1731

[TACACS+ Operation](#), on page 1732

[How to Configure Switch Access with TACACS+](#), on page 1735

[Method List](#), on page 1733

[Configuring TACACS+ Login Authentication](#), on page 1737

[TACACS+ Login Authentication](#), on page 1734

[Configuring TACACS+ Authorization for Privileged EXEC Access and Network Services](#), on page 1739

[TACACS+ Authorization for Privileged EXEC Access and Network Services](#), on page 1734



# Information About TACACS+

## TACACS+ and Switch Access

This section describes TACACS+. TACACS+ provides detailed accounting information and flexible administrative control over the authentication and authorization processes. It is facilitated through authentication, authorization, accounting (AAA) and can be enabled only through AAA commands.

### Related Topics

- [Information about Passwords and Privilege Levels](#)
- [Preventing Unauthorized Access](#), on page 1711
- [Configuring the Switch for Local Authentication and Authorization](#), on page 1839
- [SSH Servers, Integrated Clients, and Supported Versions](#), on page 1845

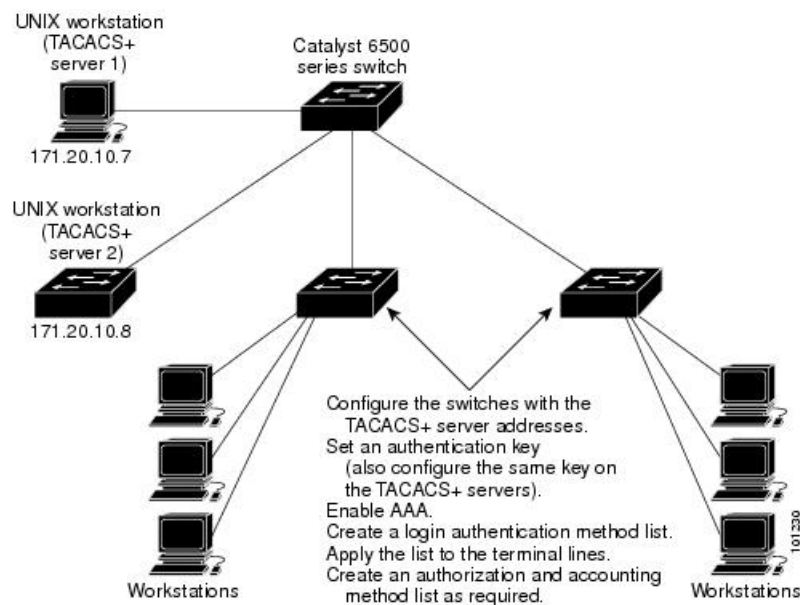
## TACACS+ Overview

TACACS+ is a security application that provides centralized validation of users attempting to gain access to your switch.

TACACS+ provides for separate and modular authentication, authorization, and accounting facilities. TACACS+ allows for a single access control server (the TACACS+ daemon) to provide each service—authentication, authorization, and accounting—independently. Each service can be tied into its own database to take advantage of other services available on that server or on the network, depending on the capabilities of the daemon.

The goal of TACACS+ is to provide a method for managing multiple network access points from a single management service. Your switch can be a network access server along with other Cisco routers and access servers.

**Figure 105: Typical TACACS+ Network Configuration**



TACACS+, administered through the AAA security services, can provide these services:

- **Authentication**—Provides complete control of authentication through login and password dialog, challenge and response, and messaging support.

The authentication facility can conduct a dialog with the user (for example, after a username and password are provided, to challenge a user with several questions, such as home address, mother's maiden name, service type, and social security number). The TACACS+ authentication service can also send messages to user screens. For example, a message could notify users that their passwords must be changed because of the company's password aging policy.

- **Authorization**—Provides fine-grained control over user capabilities for the duration of the user's session, including but not limited to setting autocommands, access control, session duration, or protocol support. You can also enforce restrictions on what commands a user can execute with the TACACS+ authorization feature.
- **Accounting**—Collects and sends information used for billing, auditing, and reporting to the TACACS+ daemon. Network managers can use the accounting facility to track user activity for a security audit or to provide information for user billing. Accounting records include user identities, start and stop times, executed commands (such as PPP), number of packets, and number of bytes.

The TACACS+ protocol provides authentication between the switch and the TACACS+ daemon, and it ensures confidentiality because all protocol exchanges between the switch and the TACACS+ daemon are encrypted.

#### Related Topics

[Prerequisites for TACACS+](#), on page 1729

## TACACS+ Operation

When a user attempts a simple ASCII login by authenticating to a switch using TACACS+, this process occurs:

1. When the connection is established, the switch contacts the TACACS+ daemon to obtain a username prompt to show to the user. The user enters a username, and the switch then contacts the TACACS+ daemon to obtain a password prompt. The switch displays the password prompt to the user, the user enters a password, and the password is then sent to the TACACS+ daemon.

TACACS+ allows a dialog between the daemon and the user until the daemon receives enough information to authenticate the user. The daemon prompts for a username and password combination, but can include other items, such as the user's mother's maiden name.

2. The switch eventually receives one of these responses from the TACACS+ daemon:
  - **ACCEPT**—The user is authenticated and service can begin. If the switch is configured to require authorization, authorization begins at this time.
  - **REJECT**—The user is not authenticated. The user can be denied access or is prompted to retry the login sequence, depending on the TACACS+ daemon.
  - **ERROR**—An error occurred at some time during authentication with the daemon or in the network connection between the daemon and the switch. If an ERROR response is received, the switch typically tries to use an alternative method for authenticating the user.
  - **CONTINUE**—The user is prompted for additional authentication information.

After authentication, the user undergoes an additional authorization phase if authorization has been enabled on the switch. Users must first successfully complete TACACS+ authentication before proceeding to TACACS+ authorization.

3. If TACACS+ authorization is required, the TACACS+ daemon is again contacted, and it returns an ACCEPT or REJECT authorization response. If an ACCEPT response is returned, the response contains data in the form of attributes that direct the EXEC or NETWORK session for that user and the services that the user can access:
  - Telnet, Secure Shell (SSH), rlogin, or privileged EXEC services
  - Connection parameters, including the host or client IP address, access list, and user timeouts

### Related Topics

[Prerequisites for TACACS+](#), on page 1729

## Method List

A method list defines the sequence and methods to be used to authenticate, to authorize, or to keep accounts on a user. You can use method lists to designate one or more security protocols to be used, thus ensuring a backup system if the initial method fails. The software uses the first method listed to authenticate, to authorize, or to keep accounts on users; if that method does not respond, the software selects the next method in the list. This process continues until there is successful communication with a listed method or the method list is exhausted.

If a method list is configured under VTY lines, the corresponding method list must be added to AAA. The following example shows how to configure a method list under a VTY line:

```
Device# configure terminal
Device(config)# line vty 0 4
Device(config)# authorization commands 15 auth1
```

The following example shows how to configure a method list in AAA:

```
Device# configure terminal
Device(config)# aaa new-model
Device(config)# aaa authorization commands 15 auth1 group tacacs+
```

If no method list is configured under VTY lines, the default method list must be added to AAA. The following example shows a VTY configuration without a method list:

```
Device# configure terminal
Device(config)# line vty 0 4
```

The following example shows how to configure the default method list:

```
Device# configure terminal
Device(config)# aaa new-model
Device(config)# aaa authorization commands 15 default group tacacs+
```

### Related Topics

[How to Configure Switch Access with TACACS+](#), on page 1735

[Prerequisites for TACACS+](#), on page 1729

## TACACS+ Configuration Options

You can configure the switch to use a single server or AAA server groups to group existing server hosts for authentication. You can group servers to select a subset of the configured server hosts and use them for a particular service. The server group is used with a global server-host list and contains the list of IP addresses of the selected server hosts.

### Related Topics

[Identifying the TACACS+ Server Host and Setting the Authentication Key](#), on page 1735

## TACACS+ Login Authentication

A method list describes the sequence and authentication methods to be queried to authenticate a user. You can designate one or more security protocols to be used for authentication, thus ensuring a backup system for authentication in case the initial method fails. The software uses the first method listed to authenticate users; if that method fails to respond, the software selects the next authentication method in the method list. This process continues until there is successful communication with a listed authentication method or until all defined methods are exhausted. If authentication fails at any point in this cycle—meaning that the security server or local username database responds by denying the user access—the authentication process stops, and no other authentication methods are attempted.

### Related Topics

[Configuring TACACS+ Login Authentication](#), on page 1737

[Prerequisites for TACACS+](#), on page 1729

## TACACS+ Authorization for Privileged EXEC Access and Network Services

AAA authorization limits the services available to a user. When AAA authorization is enabled, the switch uses information retrieved from the user's profile, which is located either in the local user database or on the security server, to configure the user's session. The user is granted access to a requested service only if the information in the user profile allows it.

### Related Topics

[Configuring TACACS+ Authorization for Privileged EXEC Access and Network Services](#), on page 1739

[Prerequisites for TACACS+](#), on page 1729

## TACACS+ Accounting

The AAA accounting feature tracks the services that users are accessing and the amount of network resources that they are consuming. When AAA accounting is enabled, the switch reports user activity to the TACACS+ security server in the form of accounting records. Each accounting record contains accounting attribute-value (AV) pairs and is stored on the security server. This data can then be analyzed for network management, client billing, or auditing.

### Related Topics

[Starting TACACS+ Accounting](#), on page 1741

## Default TACACS+ Configuration

TACACS+ and AAA are disabled by default.

To prevent a lapse in security, you cannot configure TACACS+ through a network management application. When enabled, TACACS+ can authenticate users accessing the switch through the CLI.



**Note** Although TACACS+ configuration is performed through the CLI, the TACACS+ server authenticates HTTP connections that have been configured with a privilege level of 15.

## How to Configure Switch Access with TACACS+

This section describes how to configure your switch to support TACACS+.

### Related Topics

[Method List](#), on page 1733

[Prerequisites for TACACS+](#), on page 1729

## Identifying the TACACS+ Server Host and Setting the Authentication Key

Follow these steps to identify the TACACS+ server host and set the authentication key:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>tacacs server</b> <i>server-name</i> <b>Example:</b> Device(config)# <b>tacacs server yourserver</b>	Identifies the IP host or hosts maintaining a TACACS+ server. Enter this command multiple times to create a list of preferred hosts. The software searches for hosts in the order in which you specify them.  For <i>server-name</i> , specify the server name.
<b>Step 4</b>	<b>address {ipv4   ipv6} ip address</b> <b>Example:</b> Device(config-server-tacacs)# <b>address ipv4 10.0.1.12</b>	Configures the IP address for the TACACS server.

	Command or Action	Purpose
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device (config-server-tacacs) # <b>exit</b>	Exits the TACACS server mode and enters the global configuration mode.
<b>Step 6</b>	<b>aaa new-model</b> <b>Example:</b> Device (config) # <b>aaa new-model</b>	Enables AAA.
<b>Step 7</b>	<b>aaa group server tacacs+ <i>group-name</i></b> <b>Example:</b> Device (config) # <b>aaa group server tacacs+ your_server_group</b>	(Optional) Defines the AAA server-group with a group name. This command puts the Device in a server group subconfiguration mode.
<b>Step 8</b>	<b>server <i>ip-address</i></b> <b>Example:</b> Device (config) # <b>server 10.1.1.3</b>	(Optional) Associates a particular TACACS+ server with the defined server group. Repeat this step for each TACACS+ server in the AAA server group. Each server in the group must be previously defined in Step 3.
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 10</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 11</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[TACACS+ Configuration Options](#), on page 1734

## Configuring TACACS+ Login Authentication

Follow these steps to configure TACACS+ login authentication:

### Before you begin

To configure AAA authentication, you define a named list of authentication methods and then apply that list to various ports.



**Note** To secure the for HTTP access by using AAA methods, you must configure the with the **ip http authentication aaa** global configuration command. Configuring AAA authentication does not secure the for HTTP access by using AAA methods.

For more information about the **ip http authentication** command, see the *Cisco IOS Security Command Reference, Release 12.4*.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>aaa new-model</b> <b>Example:</b> Device(config)# <b>aaa new-model</b>	Enables AAA.
<b>Step 4</b>	<b>aaa authentication login {default   list-name} method1 [method2...]</b> <b>Example:</b> Device(config)# <b>aaa authentication login default tacacs+ local</b>	Creates a login authentication method list. <ul style="list-style-type: none"> <li>• To create a default list that is used when a named list is <i>not</i> specified in the <b>login authentication</b> command, use the <b>default</b> keyword followed by the methods that are to be used in default situations. The default method list is automatically applied to all ports.</li> <li>• For <i>list-name</i>, specify a character string to name the list you are creating.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>For <i>method1...</i>, specify the actual method the authentication algorithm tries. The additional methods of authentication are used only if the previous method returns an error, not if it fails.</li> </ul> <p>Select one of these methods:</p> <ul style="list-style-type: none"> <li><i>enable</i>—Use the enable password for authentication. Before you can use this authentication method, you must define an enable password by using the <b>enable password</b> global configuration command.</li> <li><i>group tacacs+</i>—Uses TACACS+ authentication. Before you can use this authentication method, you must configure the TACACS+ server.</li> <li><i>line</i>—Use the line password for authentication. Before you can use this authentication method, you must define a line password. Use the <b>password password</b> line configuration command.</li> <li><i>local</i>—Use the local username database for authentication. You must enter username information in the database. Use the <b>username password</b> global configuration command.</li> <li><i>local-case</i>—Use a case-sensitive local username database for authentication. You must enter username information in the database by using the <b>username name password</b> global configuration command.</li> <li><i>none</i>—Do not use any authentication for login.</li> </ul>
<b>Step 5</b>	<b>line</b> [ <b>console</b>   <b>tty</b>   <b>vty</b> ] <i>line-number</i> <i>[ending-line-number]</i>  <b>Example:</b>  <pre>Device(config)# line 2 4</pre>	Enters line configuration mode, and configures the lines to which you want to apply the authentication list.
<b>Step 6</b>	<b>login authentication</b> { <b>default</b>   <i>list-name</i> }  <b>Example:</b>	Applies the authentication list to a line or set of lines.



	Command or Action	Purpose
	Device (config-line)# <b>login authentication default</b>	<ul style="list-style-type: none"> <li>• If you specify <b>default</b>, use the default list created with the <b>aaa authentication login</b> command.</li> <li>• For <i>list-name</i>, specify the list created with the <b>aaa authentication login</b> command.</li> </ul>
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device (config-line)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[TACACS+ Login Authentication](#), on page 1734

[Prerequisites for TACACS+](#), on page 1729

## Configuring TACACS+ Authorization for Privileged EXEC Access and Network Services

You can use the **aaa authorization** global configuration command with the **tacacs+** keyword to set parameters that restrict a user's network access to privileged EXEC mode.



**Note** Authorization is bypassed for authenticated users who log in through the CLI even if authorization has been configured.

Follow these steps to specify TACACS+ authorization for privileged EXEC access and network services:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>	Enables privileged EXEC mode.

	Command or Action	Purpose
	<b>Example:</b>  Device> <b>enable</b>	<ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>aaa authorization network tacacs+</b>  <b>Example:</b>  Device(config)# <b>aaa authorization network tacacs+</b>	Configures the switch for user TACACS+ authorization for all network-related service requests.
<b>Step 4</b>	<b>aaa authorization exec tacacs+</b>  <b>Example:</b>  Device(config)# <b>aaa authorization exec tacacs+</b>	Configures the switch for user TACACS+ authorization if the user has privileged EXEC access.  The <b>exec</b> keyword might return user profile information (such as <b>autocommand</b> information).
<b>Step 5</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b>  <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[TACACS+ Authorization for Privileged EXEC Access and Network Services](#), on page 1734

[Prerequisites for TACACS+](#), on page 1729

## Starting TACACS+ Accounting

Follow these steps to start TACACS+ Accounting:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>aaa accounting network start-stop tacacs+</b> <b>Example:</b> Device(config)# <b>aaa accounting network start-stop tacacs+</b>	Enables TACACS+ accounting for all network-related service requests.
<b>Step 4</b>	<b>aaa accounting exec start-stop tacacs+</b> <b>Example:</b> Device(config)# <b>aaa accounting exec start-stop tacacs+</b>	Enables TACACS+ accounting to send a start-record accounting notice at the beginning of a privileged EXEC process and a stop-record at the end.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config</b>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	startup-config	

### What to do next

To establish a session with a router if the AAA server is unreachable, use the **aaa accounting system guarantee-first** command. It guarantees system accounting as the first record, which is the default condition. In some situations, users might be prevented from starting a session on the console or terminal connection until after the system reloads, which can take more than 3 minutes.

To establish a console or Telnet session with the router if the AAA server is unreachable when the router reloads, use the **no aaa accounting system guarantee-first** command.

### Related Topics

[TACACS+ Accounting](#), on page 1734

## Establishing a Session with a Router if the AAA Server is Unreachable

To establishing a session with a router if the AAA server is unreachable, use the **aaa accounting system guarantee-first** command. It guarantees system accounting as the first record, which is the default condition. In some situations, users might be prevented from starting a session on the console or terminal connection until after the system reloads, which can take more than 3 minutes.

To establish a console or Telnet session with the router if the AAA server is unreachable when the router reloads, use the **no aaa accounting system guarantee-first** command.

## Monitoring TACACS+

*Table 128: Commands for Displaying TACACS+ Information*

Command	Purpose
show tacacs	Displays TACACS+ server statistics.



## CHAPTER 97

# MACsec Encryption

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- [Finding Feature Information, on page 1743](#)
- [Information About MACsec Encryption, on page 1743](#)
- [Configuring MKA and MACsec, on page 1752](#)
- [Configuring MACsec MKA using PSK, on page 1755](#)
- [Information About MACsec MKA using EAP-TLS, on page 1757](#)
- [Configuring MACsec MKA using EAP-TLS, on page 1758](#)
- [Cisco TrustSec Overview, on page 1773](#)
- [Configuring Cisco TrustSec MACsec, on page 1774](#)
- [Configuration Examples, on page 1776](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About MACsec Encryption

MACsec is the IEEE 802.1AE standard for authenticating and encrypting packets between two MACsec-capable devices. These Catalyst switches support 802.1AE encryption with MACsec Key Agreement (MKA) on downlink ports for encryption between the switch and host device. The switch also supports MACsec encryption for switch-to-switch (inter-network device) security using both Cisco TrustSec Network Device Admission Control (NDAC), Security Association Protocol (SAP) and MKA-based key exchange protocol. Link layer security can include both packet authentication between switches and MACsec encryption between switches (encryption is optional).



---

**Note** MACsec is not supported with the NPE license or the LAN Base service image.

---

Table 129: MACsec Support on Switch Ports

Interface	Connections	MACsec support
Downlink ports	Switch-to-host	MACsec MKA encryption
Uplink ports	Switch-to-switch	MACsec MKA encryption Cisco TrustSec NDAC MACsec

Cisco TrustSec and Cisco SAP are meant only for switch-to-switch links and are not supported on switch ports connected to end hosts, such as PCs or IP phones. MKA is supported on switch-to-host facing links (downlink) as well as switch-to-switch links (uplink). Host-facing links typically use flexible authentication ordering for handling heterogeneous devices with or without IEEE 802.1x, and can optionally use MKA-based MACsec encryption. Cisco NDAC and SAP are mutually exclusive with Network Edge Access Topology (NEAT), which is used for compact switches to extend security outside the wiring closet.

## Media Access Control Security and MACsec Key Agreement

MACsec, defined in 802.1AE, provides MAC-layer encryption over wired networks by using out-of-band methods for encryption keying. The MACsec Key Agreement (MKA) Protocol provides the required session keys and manages the required encryption keys. MKA and MACsec are implemented after successful authentication using the 802.1x Extensible Authentication Protocol (EAP-TLS) or Pre Shared Key (PSK) framework.

A switch using MACsec accepts either MACsec or non-MACsec frames, depending on the policy associated with the MKA peer. MACsec frames are encrypted and protected with an integrity check value (ICV). When the switch receives frames from the MKA peer, it decrypts them and calculates the correct ICV by using session keys provided by MKA. The switch compares that ICV to the ICV within the frame. If they are not identical, the frame is dropped. The switch also encrypts and adds an ICV to any frames sent over the secured port (the access point used to provide the secure MAC service to a MKA peer) using the current session key.

The MKA Protocol manages the encryption keys used by the underlying MACsec protocol. The basic requirements of MKA are defined in 802.1x-REV. The MKA Protocol extends 802.1x to allow peer discovery with confirmation of mutual authentication and sharing of MACsec secret keys to protect data exchanged by the peers.

The EAP framework implements MKA as a newly defined EAP-over-LAN (EAPOL) packet. EAP authentication produces a master session key (MSK) shared by both partners in the data exchange. Entering the EAP session ID generates a secure connectivity association key name (CKN). The switch acts as the authenticator for both uplink and downlink; and acts as the key server for downlink. It generates a random secure association key (SAK), which is sent to the client partner. The client is never a key server and can only interact with a single MKA entity, the key server. After key derivation and generation, the switch sends periodic transports to the partner at a default interval of 2 seconds.

The packet body in an EAPOL Protocol Data Unit (PDU) is referred to as a MACsec Key Agreement PDU (MKPDU). MKA sessions and participants are deleted when the MKA lifetime (6 seconds) passes with no MKPDU received from a participant. For example, if a MKA peer disconnects, the participant on the switch continues to operate MKA until 6 seconds have elapsed after the last MKPDU is received from the MKA peer.



---

**Note** Integrity check value (ICV) indicator in MKPDU is optional. ICV is not optional when the traffic is encrypted.

---

EAPoL Announcements indicate the use of the type of keying material. The announcements can be used to announce the capability of the supplicant as well as the authenticator. Based on the capability of each side, the largest common denominator of the keying material could be used.

Prior to Cisco IOS XE Fuji 16.8.1a, should-secure was supported for MKA and SAP. With should-secure enabled, if the peer is configured for MACsec, the data traffic is encrypted, otherwise it is sent in clear text. Starting with Cisco IOS XE Fuji 16.8.1a, must-secure support is enabled on both the ingress and the egress. Must-secure is supported for MKA and SAP. With must-secure enabled, only EAPoL traffic will not be encrypted. The rest of the traffic will be encrypted. Unencrypted packets are dropped.



---

**Note** Must-secure mode is enabled by default.

---

## MKA Policies

To enable MKA on an interface, a defined MKA policy should be applied to the interface. You can configure these options:

- Policy name, not to exceed 16 ASCII characters.
- Confidentiality (encryption) offset of 0, 30, or 50 bytes for each physical interface

## Virtual Ports

Use virtual ports for multiple secured connectivity associations on a single physical port. Each connectivity association (pair) represents a virtual port. In uplink, you can have only one virtual port per physical port. In downlink, you can have a maximum of two virtual ports per physical port, of which one virtual port can be part of a data VLAN; the other must externally tag its packets for the voice VLAN. You cannot simultaneously host secured and unsecured sessions in the same VLAN on the same port. Because of this limitation, 802.1x multiple authentication mode is not supported.

The exception to this limitation is in multiple-host mode when the first MACsec supplicant is successfully authenticated and connected to a hub that is connected to the switch. A non-MACsec host connected to the hub can send traffic without authentication because it is in multiple-host mode. We do not recommend using multi-host mode because after the first successful client, authentication is not required for other clients.

Virtual ports represent an arbitrary identifier for a connectivity association and have no meaning outside the MKA Protocol. A virtual port corresponds to a separate logical port ID. Valid port IDs for a virtual port are 0x0002 to 0xFFFF. Each virtual port receives a unique secure channel identifier (SCI) based on the MAC address of the physical interface concatenated with a 16-bit port ID.

## MACsec and Stacking

A switch stack master running MACsec maintains the configuration files that show which ports on a member switch support MACsec. The stack master performs these functions:

- Processes secure channel and secure association creation and deletion
- Sends secure association service requests to the stack members.

- Processes packet number and replay-window information from local or remote ports and notifies the key management protocol.
- Sends MACsec initialization requests with the globally configured options to new switches that are added to the stack.
- Sends any per-port configuration to the member switches.

A member switch performs these functions:

- Processes MACsec initialization requests from the stack master.
- Processes MACsec service requests sent by the stack master.
- Sends information about local ports to the stack master.

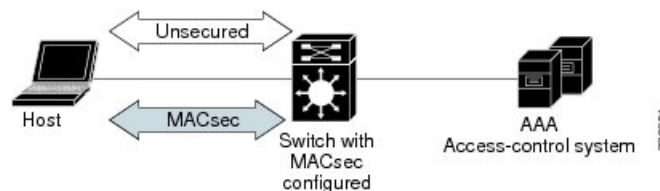
## MACsec, MKA and 802.1x Host Modes

You can use MACsec and the MKA Protocol with 802.1x single-host mode, multi-host mode, or Multi Domain Authentication (MDA) mode. Multiple authentication mode is not supported.

### Single-Host Mode

The figure shows how a single EAP authenticated session is secured by MACsec by using MKA

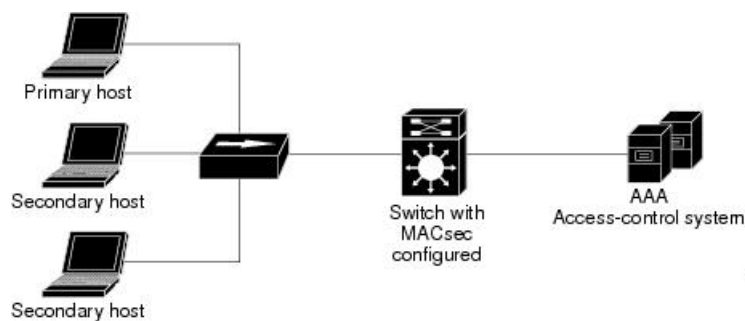
**Figure 106: MACsec in Single-Host Mode with a Secured Data Session**



### Multiple Host Mode

In standard (not 802.1x REV) 802.1x multiple-host mode, a port is open or closed based on a single authentication. If one user, the primary secured client services client host, is authenticated, the same level of network access is provided to any host connected to the same port. If a secondary host is a MACsec supplicant, it cannot be authenticated and traffic would not flow. A secondary host that is a non-MACsec host can send traffic to the network without authentication because it is in multiple-host mode. The figure shows MACsec in Standard Multiple-Host Unsecure Mode.

**Figure 107: MACsec in Multiple-Host Mode - Unsecured**







```
Key Server..... YES
MKA Cipher Suite..... AES-128-CMAC

Latest SAK Status..... Rx & Tx
Latest SAK AN..... 0
Latest SAK KI (KN)..... D46CBEC05D5D67594543CEAE00000001 (1)
Old SAK Status..... FIRST-SAK
Old SAK AN..... 0
Old SAK KI (KN)..... FIRST-SAK (0)

SAK Transmit Wait Time... 0s (Not waiting for any peers to respond)
SAK Retire Time..... 0s (No Old SAK to retire)

MKA Policy Name..... p2
Key Server Priority..... 2
Delay Protection..... NO
Replay Protection..... YES
Replay Window Size..... 0
Confidentiality Offset... 0
Algorithm Agility..... 80C201
Send Secure Announcement.. DISABLED
SAK Cipher Suite..... 0080C20001000001 (GCM-AES-128)
MACsec Capability..... 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired..... YES

# of MACsec Capable Live Peers..... 1
# of MACsec Capable Live Peers Responded.. 1

Live Peers List:
    MI                      MN                Rx-SCI (Peer)           KS Priority
-----
    38046BA37D7DA77E06D006A9 89555           c800.8459.e764/002a    10

Potential Peers List:
    MI                      MN                Rx-SCI (Peer)           KS Priority
-----

Dormant Peers List:
    MI                      MN                Rx-SCI (Peer)           KS Priority
-----

Switch#show mka sessions de
Switch#show mka sessions detail

MKA Detailed Status for MKA Session
=====
Status: SECURED - Secured MKA Session with MACsec

Local Tx-SCI..... 204c.9e85.ede4/002b
Interface MAC Address... 204c.9e85.ede4
MKA Port Identifier..... 43
Interface Name..... GigabitEthernet1/0/1
Audit Session ID.....
CAK Name (CKN)..... 0100000000000000000000000000000000000000000000000000000000000000
Member Identifier (MI)... D46CBEC05D5D67594543CEAE
Message Number (MN)..... 89572
EAP Role..... NA
Key Server..... YES
MKA Cipher Suite..... AES-128-CMAC

Latest SAK Status..... Rx & Tx
Latest SAK AN..... 0
Latest SAK KI (KN)..... D46CBEC05D5D67594543CEAE00000001 (1)
Old SAK Status..... FIRST-SAK
```

```

Old SAK AN..... 0
Old SAK KI (KN)..... FIRST-SAK (0)

SAK Transmit Wait Time... 0s (Not waiting for any peers to respond)
SAK Retire Time..... 0s (No Old SAK to retire)

MKA Policy Name..... p2
Key Server Priority..... 2
Delay Protection..... NO
Replay Protection..... YES
Replay Window Size..... 0
Confidentiality Offset... 0
Algorithm Agility..... 80C201
SAK Cipher Suite..... 0080C20001000001 (GCM-AES-128)
MACsec Capability..... 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired..... YES

# of MACsec Capable Live Peers..... 1
# of MACsec Capable Live Peers Responded.. 1

```

## Live Peers List:

```

MI                MN                Rx-SCI (Peer)      KS Priority
-----
38046BA37D7DA77E06D006A9  89560          c800.8459.e764/002a  10

```

## Potential Peers List:

```

MI                MN                Rx-SCI (Peer)      KS Priority
-----

```

## Dormant Peers List:

```

MI                MN                Rx-SCI (Peer)      KS Priority
-----

```

```
Switch#sh mka pol
```

## MKA Policy Summary...

Policy Name	KS Priority	Delay Protect	Replay Protect	Window Size	Conf Offset	Cipher Suite(s)	Interfaces Applied
*DEFAULT POLICY*	0	FALSE	TRUE	0	0	GCM-AES-128	
p1	1	FALSE	TRUE	0	0	GCM-AES-128	
p2	2	FALSE	TRUE	0	0	GCM-AES-128	Gi1/0/1

```
Switch#sh mka poli
```

```
Switch#sh mka policy p2
```

```
Switch#sh mka policy p2 ?
```

```

  detail    Detailed configuration/information for MKA Policy
  sessions  Summary of all active MKA Sessions with policy applied
  |         Output modifiers
  <cr>

```

```
Switch#sh mka policy p2 de
```

## MKA Policy Configuration ("p2")

```

=====
MKA Policy Name..... p2
Key Server Priority.... 2
Confidentiality Offset. 0
Send Secure Announcement..DISABLED
Cipher Suite(s)..... GCM-AES-128

```

```
Applied Interfaces...
  GigabitEthernet1/0/1
```

```
Switch#sh mka policy p2
```

```
MKA Policy Summary...
```

Policy Name	KS Priority	Delay Protect	Replay Protect	Window Size	Conf Offset	Cipher Suite(s)	Interfaces Applied
p2	2	FALSE	TRUE	0	0	GCM-AES-128	Gi1/0/1

```
Switch#sh mka se?
sessions
```

```
Switch#sh mka ?
  default-policy  MKA Default Policy details
  keychains       MKA Pre-Shared-Key Key-Chains
  policy          MKA Policy configuration information
  presharedkeys  MKA Preshared Keys
  sessions        MKA Sessions summary
  statistics      Global MKA statistics
  summary        MKA Sessions summary & global statistics
```

```
Switch#sh mka statis
Switch#sh mka statistics ?
  interface  Statistics for a MKA Session on an interface
  local-sci  Statistics for a MKA Session identified by its Local Tx-SCI
  |          Output modifiers
<cr>
```

```
Switch#sh mka statistics inter
Switch#show mka statistics interface G1/0/1
```

```
MKA Statistics for Session
=====
Reauthentication Attempts.. 0
```

```
CA Statistics
  Pairwise CAKs Derived... 0
  Pairwise CAK Rekeys..... 0
  Group CAKs Generated.... 0
  Group CAKs Received..... 0
```

```
SA Statistics
  SAKs Generated..... 1
  SAKs Rekeyed..... 0
  SAKs Received..... 0
  SAK Responses Received.. 1
```

```
MKPDU Statistics
  MKPDUs Validated & Rx... 89585
    "Distributed SAK".. 0
    "Distributed CAK".. 0
  MKPDUs Transmitted..... 89596
    "Distributed SAK".. 1
    "Distributed CAK".. 0
```

```
Switch#show mka ?
  default-policy  MKA Default Policy details
  keychains       MKA Pre-Shared-Key Key-Chains
```



```

SAK Cipher Mismatch..... 0

CA Failures
  Group CAK Generation..... 0
  Group CAK Encryption/Wrap..... 0
  Group CAK Decryption/Unwrap..... 0
  Pairwise CAK Derivation..... 0
  CKN Derivation..... 0
  ICK Derivation..... 0
  KEK Derivation..... 0
  Invalid Peer MACsec Capability... 0
MACsec Failures
  Rx SC Creation..... 0
  Tx SC Creation..... 0
  Rx SA Installation..... 0
  Tx SA Installation..... 0

MKPDU Failures
  MKPDU Tx..... 0
  MKPDU Rx Validation..... 0
  MKPDU Rx Bad Peer MN..... 0
  MKPDU Rx Non-recent Peerlist MN.. 0

Switch#

```

## Configuring MKA and MACsec

### Default MACsec MKA Configuration

MACsec is disabled. No MKA policies are configured.

### Configuring an MKA Policy

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>configure terminal</code>	Enter global configuration mode.
<b>Step 2</b>	<code>mka policy <i>policy name</i></code>	Identify an MKA policy, and enter MKA policy configuration mode. The maximum policy name length is 16 characters.  <b>Note</b> The default MACsec cipher suite in the MKA policy will always be "GCM-AES-128". If the device supports both "GCM-AES-128" and "GCM-AES-256" ciphers, it is highly recommended to define and use a user defined MKA policy to include both 128 and 256 bits ciphers or only 256 bits cipher, as may be required.

	Command or Action	Purpose
<b>Step 3</b>	<code>send-secure-announcements</code>	Enabled secure announcements. <b>Note</b> By default, secure announcements are disabled.
<b>Step 4</b>	<code>key-server priority</code>	Configure MKA key server options and set priority (between 0-255). <b>Note</b> When value of key server priority is set to 255, the peer can not become the key server. The key server priority value is valid only for MKA PSK; and not for MKA EAPTLS.
<b>Step 5</b>	<code>include-icv-indicator</code>	Enables the ICV indicator in MKPDU. Use the <b>no</b> form of this command to disable the ICV indicator — <b>no include-icv-indicator</b> .
<b>Step 6</b>	<code>macsec-cipher-suite gcm-aes-128</code>	Configures cipher suite for deriving SAK with 128-bit encryption.
<b>Step 7</b>	<code>confidentiality-offset</code> <i>Offset value</i>	Set the Confidentiality (encryption) offset for each physical interface <b>Note</b> Offset Value can be 0, 30 or 50. If you are using Anyconnect on the client, it is recommended to use Offset 0.
<b>Step 8</b>	<code>end</code>	Returns to privileged EXEC mode.
<b>Step 9</b>	<code>show mka policy</code>	Verify your entries.

### Example

This example configures the MKA policy:

```
Switch(config)# mka policy mka_policy
Switch(config-mka-policy)# key-server priority 200
Switch(config-mka-policy)# macsec-cipher-suite gcm-aes-128
Switch(config-mka-policy)# confidentiality-offset 30
Switch(config-mka-policy)# end
```

## Configuring MACsec on an Interface

Follow these steps to configure MACsec on an interface with one MACsec session for voice and one for data:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Switch>enable	Enables privileged EXEC mode. Enter the password if prompted.
<b>Step 2</b>	<b>configureterminal</b> <b>Example:</b> Switch>configure terminal	Enters the global configuration mode.
<b>Step 3</b>	<b>interface interface-id</b>	Identify the MACsec interface, and enter interface configuration mode. The interface must be a physical interface.
<b>Step 4</b>	<b>switchport access vlanvlan-id</b>	Configure the access VLAN for the port.
<b>Step 5</b>	<b>switchport mode access</b>	Configure the interface as an access port.
<b>Step 6</b>	<b>macsec</b>	Enable 802.1ae MACsec on the interface. The macsec command enables MKA MACsec on switch-to-host links (downlink ports) only.
<b>Step 7</b>	<b>authentication event linksec fail action authorize vlan vlan-id</b>	(Optional) Specify that the switch processes authentication link-security failures resulting from unrecognized user credentials by authorizing a restricted VLAN on the port after a failed authentication attempt.
<b>Step 8</b>	<b>authentication host-mode multi-domain</b>	Configure authentication manager mode on the port to allow both a host and a voice device to be authenticated on the 802.1x-authorized port. If not configured, the default host mode is single.
<b>Step 9</b>	<b>authentication linksec policy must-secure</b>	Set the LinkSec security policy to secure the session with MACsec if the peer is available. If not set, the default is <i>should secure</i> .
<b>Step 10</b>	<b>authentication port-control auto</b>	Enable 802.1x authentication on the port. The port changes to the authorized or unauthorized state based on the authentication exchange between the switch and the client.
<b>Step 11</b>	<b>authentication periodic</b>	Enable or Disable Reauthentication for this port .
<b>Step 12</b>	<b>authentication timer reauthenticate</b>	Enter a value between 1 and 65535 (in seconds). Obtains re-authentication timeout value from the server. Default re-authentication time is 3600 seconds.



	Command or Action	Purpose
Step 13	<b>authentication violation protect</b>	Configure the port to drop unexpected incoming MAC addresses when a new device connects to a port or when a device connects to a port after the maximum number of devices are connected to that port. If not configured, the default is to shut down the port.
Step 14	<b>mka policy</b> <i>policy name</i>	Apply an existing MKA protocol policy to the interface, and enable MKA on the interface. If no MKA policy was configured (by entering the <b>mka policy</b> global configuration command).
Step 15	<b>dot1x pae authenticator</b>	Configure the port as an 802.1x port access entity (PAE) authenticator.
Step 16	<b>spanning-tree portfast</b>	Enable spanning tree Port Fast on the interface in all its associated VLANs. When Port Fast feature is enabled, the interface changes directly from a blocking state to a forwarding state without making the intermediate spanning-tree state changes
Step 17	<b>end</b>  <b>Example:</b> <code>Switch(config)#end</code>	Returns to privileged EXEC mode.
Step 18	<b>show authentication session interface</b> <i>interface-id</i>	Verify the authorized session security status.
Step 19	<b>show authentication session interface</b> <i>interface-id</i> details	Verify the details of the security status of the authorized session.
Step 20	<b>show macsec interface</b> <i>interface-id</i>	Verify MacSec status on the interface.
Step 21	<b>show mka sessions</b>	Verify the established mka sessions.
Step 22	<b>copy running-config startup-config</b>  <b>Example:</b> <code>Switch#copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring MACsec MKA using PSK

### Procedure

	Command or Action	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.

	Command or Action	Purpose
Step 2	<b>key chain</b> <i>key-chain-name</i> <b>macsec</b>	Configures a key chain and enters the key chain configuration mode.
Step 3	<b>key</b> <i>hex-string</i>	Configures a unique identifier for each key in the keychain and enters the keychain's key configuration mode.  <b>Note</b> For 128-bit encryption, use 32 hex digit key-string. For 256-bit encryption, use 64 hex digit key-string.
Step 4	<b>cryptographic-algorithm</b> { <i>gcm-aes-128</i>   <i>gcm-aes-256</i> }	Set cryptographic authentication algorithm with 128-bit or 256-bit encryption.
Step 5	<b>key-string</b> { [0 6 7] <i>pwd-string</i>   <i>pwd-string</i> }	Sets the password for a key string. Only hex characters must be entered.
Step 6	<b>lifetime local</b> [ <i>start timestamp {hh::mm::ss   day   month   year}</i> ] [ <b>duration</b> <i>seconds</i>   <i>end timestamp {hh::mm::ss   day   month   year}</i> ]	Sets the lifetime of the pre shared key.
Step 7	<b>end</b>	Returns to privileged EXEC mode.

### Example

Following is an indicative example:

```
Switch(config)# Key chain keychain1 macsec
Switch(config-key-chain)# key 1000
Switch(config-keychain-key)# cryptographic-algorithm gcm-aes-128
Switch(config-keychain-key)# key-string 12345678901234567890123456789012
Switch(config-keychain-key)# lifetime local 12:12:00 July 28 2016 12:19:00 July
28 2016
Switch(config-keychain-key)# end
```

## Configuring MACsec MKA on an Interface using PSK



**Note** To avoid traffic drop across sessions, the **mka policy** command must be configured before the **mka pre-shared-key key-chain** command.

### Procedure

	Command or Action	Purpose
Step 1	<b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<code>interface <i>interface-id</i></code>	Enters interface configuration mode.
<b>Step 3</b>	<code>macsec network-link</code>	Enables MACsec on the interface.
<b>Step 4</b>	<code>mka policy <i>policy-name</i></code>	Configures an MKA policy.
<b>Step 5</b>	<code>mka pre-shared-key key-chain <i>key-chain name</i></code>	Configures an MKA pre-shared-key key-chain name.  <b>Note</b> The MKA pre-shared key can be configured on either physical interface or sub-interfaces and not on both.
<b>Step 6</b>	<code>macsec replay-protection window-size <i>frame number</i></code>	Sets the MACsec window size for replay protection.
<b>Step 7</b>	<code>end</code>	Returns to privileged EXEC mode.

### Example

Following is an indicative example:

```
Switch(config)# interface GigabitEthernet 0/0/0
Switch(config-if)# mka policy mka_policy
Switch(config-if)# mka pre-shared-key key-chain key-chain-name
Switch(config-if)# macsec replay-protection window-size 10
Switch(config-if)# end
```

### What to do next

It is not recommended to change the MKA policy on an interface with MKA PSK configured when the session is running. However, if a change is required, you must reconfigure the policy as follows:

1. Disable the existing session by removing `macsec network-link` configuration on each of the participating node using the **no macsec network-link** command
2. Configure the MKA policy on the interface on each of the participating node using the **mka policy policy-name** command.
3. Enable the new session on each of the participating node by using the **macsec network-link** command.

## Information About MACsec MKA using EAP-TLS

MACsec MKA is supported on switch-to-switch links. Using IEE 802.1X Port-based Authentication with Extensible Authentication Protocol (EAP-TLS), you can configure MACsec MKA between device uplink ports. EAP-TLS allows mutual authentication and obtains an MSK (master session key) from which the connectivity association key (CAK) is derived for MKA operations. Device certificates are carried, using EAP-TLS, for authentication to the AAA server.

## Prerequisites for MACsec MKA using EAP-TLS

- Ensure that you have a Certificate Authority (CA) server configured for your network.
- Generate a CA certificate.
- Ensure that you have configured Cisco Identity Services Engine (ISE) Release 2.0.
- Ensure that both the participating devices, the CA server, and Cisco Identity Services Engine (ISE) are synchronized using Network Time Protocol (NTP). If time is not synchronized on all your devices, certificates will not be validated.
- Ensure that 802.1x authentication and AAA are configured on your device.

## Limitations for MACsec MKA using EAP-TLS

- MKA is not supported on port-channels.
- MKA is not supported with High Availability and local authentication.
- MKA/EAPTLS is not supported for promiscuous PVLAN Primary port.
- While configuring MACsec MKA using EAP-TLS, MACsec secure channels encrypt counters does not increment before first Rekey.
- 

## Configuring MACsec MKA using EAP-TLS

To configure MACsec with MKA on point-to-point links, perform these tasks:

- Configure Certificate Enrollment
  - Generate Key Pairs
  - Configure SCEP Enrollment
  - Configure Certificates Manually
- Configure an Authentication Policy
- Configure EAP-TLS Profiles and IEEE 802.1x Credentials
- Configure MKA MACsec using EAP-TLS on Interfaces

## Remote Authentication

### Generating Key Pairs

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>configure terminal</code>	Enter global configuration mode.
<b>Step 2</b>	<code>crypto key generate rsa label <i>label-name</i> general-keys modulus <i>size</i></code>	Generates a RSA key pair for signing and encryption.  You can also assign a label to each key pair using the label keyword. The label is referenced by the trustpoint that uses the key pair. If you do not assign a label, the key pair is automatically labeled <Default-RSA-Key>.  If you do not use additional keywords this command generates one general purpose RSA key pair. If the modulus is not specified, the default key modulus of 1024 is used. You can specify other modulus sizes with the modulus keyword.
<b>Step 3</b>	<code>end</code>	Returns to privileged EXEC mode.
<b>Step 4</b>	<code>show authentication session interface <i>interface-id</i></code>	Verifies the authorized session security status.
<b>Step 5</b>	<code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

### Configuring Enrollment using SCEP

Simple Certificate Enrollment Protocol (SCEP) is a Cisco-developed enrollment protocol that uses HTTP to communicate with the certificate authority (CA) or registration authority (RA). SCEP is the most commonly used method for sending and receiving requests and certificates.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>configure terminal</code>	Enter global configuration mode.
<b>Step 2</b>	<code>crypto pki trustpoint <i>server name</i></code>	Declares the trustpoint and a given name and enters ca-trustpoint configuration mode.
<b>Step 3</b>	<code>enrollment url <i>url name pem</i></code>	Specifies the URL of the CA on which your device should send certificate requests.

	Command or Action	Purpose
		<p>An IPv6 address can be added in the URL enclosed in brackets. For example: http://[2001:DB8:1:1::1]:80.</p> <p>The pem keyword adds privacy-enhanced mail (PEM) boundaries to the certificate request.</p>
<b>Step 4</b>	<b>rsa</b> keypair <i>label</i>	<p>Specifies which key pair to associate with the certificate.</p> <p><b>Note</b> The <b>rsa</b>keypair name must match the trust-point name.</p>
<b>Step 5</b>	<b>serial-number none</b>	The <b>none</b> keyword specifies that a serial number will not be included in the certificate request.
<b>Step 6</b>	<b>ip-address none</b>	The <b>none</b> keyword specifies that no IP address should be included in the certificate request.
<b>Step 7</b>	<b>revocation-check crl</b>	Specifies CRL as the method to ensure that the certificate of a peer has not been revoked.
<b>Step 8</b>	<b>auto-enroll</b> <i>percent</i> <b>regenerate</b>	<p>Enables auto-enrollment, allowing the client to automatically request a rollover certificate from the CA.</p> <p>If auto-enrollment is not enabled, the client must be manually re-enrolled in your PKI upon certificate expiration.</p> <p>By default, only the Domain Name System (DNS) name of the device is included in the certificate.</p> <p>Use the percent argument to specify that a new certificate will be requested after the percentage of the lifetime of the current certificate is reached.</p> <p>Use the regenerate keyword to generate a new key for the certificate even if a named key already exists.</p> <p>If the key pair being rolled over is exportable, the new key pair will also be exportable. The following comment will appear in the trustpoint configuration to indicate whether the key pair is exportable: “! RSA key pair associated with trustpoint is exportable.”</p> <p>It is recommended that a new key pair be generated for security reasons.</p>

	Command or Action	Purpose
Step 9	<code>crypto pki authenticate name</code>	Retrieves the CA certificate and authenticates it.
Step 10	<code>exit</code>	Exits global configuration mode.
Step 11	<code>show crypto pki certificate trustpoint name</code>	Displays information about the certificate for the trust point.

## Configuring Enrollment Manually

If your CA does not support SCEP or if a network connection between the router and CA is not possible. Perform the following task to set up manual certificate enrollment:

### Procedure

	Command or Action	Purpose
Step 1	<code>configure terminal</code>	Enter global configuration mode.
Step 2	<code>crypto pki trustpoint server name</code>	Declares the trustpoint and a given name and enters ca-trustpoint configuration mode.
Step 3	<code>enrollment url url name pem</code>	Specifies the URL of the CA on which your device should send certificate requests.  An IPv6 address can be added in the URL enclosed in brackets. For example: <code>http://[2001:DB8:1:1::1]:80</code> .  The pem keyword adds privacy-enhanced mail (PEM) boundaries to the certificate request.
Step 4	<code>rsa keypair label</code>	Specifies which key pair to associate with the certificate.
Step 5	<code>serial-number none</code>	The <b>none</b> keyword specifies that a serial number will not be included in the certificate request.
Step 6	<code>ip-address none</code>	The <b>none</b> keyword specifies that no IP address should be included in the certificate request.
Step 7	<code>revocation-check crl</code>	Specifies CRL as the method to ensure that the certificate of a peer has not been revoked.
Step 8	<code>exit</code>	Exits Global Configuration mode.
Step 9	<code>crypto pki authenticate name</code>	Retrieves the CA certificate and authenticates it.
Step 10	<code>crypto pki enroll name</code>	Generates certificate request and displays the request for copying and pasting into the certificate server.

	Command or Action	Purpose
		<p>Enter enrollment information when you are prompted. For example, specify whether to include the device FQDN and IP address in the certificate request.</p> <p>You are also given the choice about displaying the certificate request to the console terminal.</p> <p>The base-64 encoded certificate with or without PEM headers as requested is displayed.</p>
<b>Step 11</b>	<b>crypto pki import <i>name</i> certificate</b>	<p>Imports a certificate via TFTP at the console terminal, which retrieves the granted certificate.</p> <p>The device attempts to retrieve the granted certificate via TFTP using the same filename used to send the request, except the extension is changed from “.req” to “.crt”. For usage key certificates, the extensions “-sign.crt” and “-encr.crt” are used.</p> <p>The device parses the received files, verifies the certificates, and inserts the certificates into the internal certificate database on the switch.</p> <p><b>Note</b> Some CAs ignore the usage key information in the certificate request and issue general purpose usage certificates. If your CA ignores the usage key information in the certificate request, only import the general purpose certificate. The router will not use one of the two key pairs generated.</p>
<b>Step 12</b>	<b>exit</b>	Exits global configuration mode.
<b>Step 13</b>	<b>show crypto pki certificate <i>trustpoint name</i></b>	Displays information about the certificate for the trust point.
<b>Step 14</b>	<b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Enabling 802.1x Authentication and Configuring AAA

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>



	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>aaa new-model</b>	Enables AAA.
<b>Step 4</b>	<b>dot1x system-auth-control</b>	Enables 802.1X on your device.
<b>Step 5</b>	<b>radius server</b> <i>name</i>	Specifies the name of the RADIUS server configuration for Protected Access Credential (PAC) provisioning and enters RADIUS server configuration mode.
<b>Step 6</b>	<b>address</b> <i>ip-address</i> <b>auth-port</b> <i>port-number</i> <b>acct-port</b> <i>port-number</i>	Configures the IPv4 address for the RADIUS server accounting and authentication parameters.
<b>Step 7</b>	<b>automate-tester</b> <b>username</b> <i>username</i>	Enables the automated testing feature for the RADIUS server.  With this practice, the device sends periodic test authentication messages to the RADIUS server. It looks for a RADIUS response from the server. A success message is not necessary - a failed authentication suffices, because it shows that the server is alive.
<b>Step 8</b>	<b>key</b> <i>string</i>	Configures the authentication and encryption key for all RADIUS communications between the device and the RADIUS server.
<b>Step 9</b>	<b>radius-server</b> <b>deadtime</b> <i>minutes</i>	Improves RADIUS response time when some servers might be unavailable and skips unavailable servers immediately.
<b>Step 10</b>	<b>exit</b>	Returns to global configuration mode.
<b>Step 11</b>	<b>aaa group server radius</b> <i>group-name</i>	Groups different RADIUS server hosts into distinct lists and distinct methods, and enters server group configuration mode.
<b>Step 12</b>	<b>server</b> <i>name</i>	Assigns the RADIUS server name.
<b>Step 13</b>	<b>exit</b>	Returns to global configuration mode.
<b>Step 14</b>	<b>aaa authentication dot1x default group</b> <i>group-name</i>	Sets the default authentication server group for IEEE 802.1x.
<b>Step 15</b>	<b>aaa authorization network default group</b> <i>group-name</i>	Sets the network authorization default group.

## Configuring EAP-TLS Profile and 802.1x Credentials

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>enable</code>	Enables privileged EXEC mode. • Enter your password if prompted.
<b>Step 2</b>	<code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<code>eap profile <i>profile-name</i></code>	Configures EAP profile and enters EAP profile configuration mode.
<b>Step 4</b>	<code>method tls</code>	Enables EAP-TLS method on the device.
<b>Step 5</b>	<code>pki-trustpoint <i>name</i></code>	Sets the default PKI trustpoint.
<b>Step 6</b>	<code>exit</code>	Returns to global configuration mode.
<b>Step 7</b>	<code>dot1x credentials <i>profile-name</i></code>	Configures 802.1x credentials profile and enters dot1x credentials configuration mode.
<b>Step 8</b>	<code>username <i>username</i></code>	Sets the authentication user ID.
<b>Step 9</b>	<code>pki-trustpoint <i>name</i></code>	Sets the default PKI trustpoint.
<b>Step 10</b>	<code>end</code>	Returns to privileged EXEC mode.

## Applying the 802.1x MACsec MKA Configuration on Interfaces

To apply MACsec MKA using EAP-TLS to interfaces, perform the following task:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<code>interface <i>interface-id</i></code>	Identifies the MACsec interface, and enter interface configuration mode. The interface must be a physical interface.
<b>Step 3</b>	<code>macsec network-link</code>	Enables MACsec on the interface.
<b>Step 4</b>	<code>authentication periodic</code>	Enables reauthentication for this port.
<b>Step 5</b>	<code>authentication timer reauthenticate interval</code>	Sets the reauthentication interval.
<b>Step 6</b>	<code>access-session host-mode multi-domain</code>	Allows hosts to gain access to the interface.
<b>Step 7</b>	<code>access-session closed</code>	Prevents preauthentication access on the interface.

	Command or Action	Purpose
<b>Step 8</b>	<b>access-session port-control auto</b>	Sets the authorization state of a port.
<b>Step 9</b>	<b>dot1x pae both</b>	Configures the port as an 802.1X port access entity (PAE) supplicant and authenticator.
<b>Step 10</b>	<b>dot1x credentials profile</b>	Assigns a 802.1x credentials profile to the interface.
<b>Step 11</b>	<b>dot1x supplicant eap profile <i>name</i></b>	Assigns the EAP-TLS profile to the interface.
<b>Step 12</b>	<b>service-policy type control subscriber <i>control-policy name</i></b>	Applies a subscriber control policy to the interface.
<b>Step 13</b>	<b>exit</b>	Returns to privileged EXEC mode.
<b>Step 14</b>	<b>show macsec interface</b>	Displays MACsec details for the interface.
<b>Step 15</b>	<b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Local Authentication

### Configuring the EAP Credentials using Local Authentication

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>aaa new-model</b>	Enables AAA.
<b>Step 4</b>	<b>aaa local authentication default authorization default</b>	Sets the default local authentication and default local authorization method.
<b>Step 5</b>	<b>aaa authentication dot1x default local</b>	Sets the default local username authentication list for IEEE 802.1x.
<b>Step 6</b>	<b>aaa authorization network default local</b>	Sets an authorization method list for local user.
<b>Step 7</b>	<b>aaa authorization credential-download default local</b>	Sets an authorization method list for use of local credentials.
<b>Step 8</b>	<b>exit</b>	Returns to privileged EXEC mode.

## Configuring the Local EAP-TLS Authentication and Authorization Profile

### Procedure

	Command or Action	Purpose
Step 1	<b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
Step 2	<b>configure terminal</b>	Enters global configuration mode.
Step 3	<b>aaa new-model</b>	Enables AAA.
Step 4	<b>dot1x credentials</b> <i>profile-name</i>	Configures the dot1x credentials profile and enters dot1x credentials configuration mode.
Step 5	<b>username</b> <i>name</i> <b>password</b> <i>password</i>	Sets the authentication user ID and password.
Step 6	<b>exit</b>	Returns to global configuration mode.
Step 7	<b>aaa attribute list</b> <i>list-name</i>	(Optional) Sets the AAA attribute list definition and enters attribute list configuration mode.
Step 8	<b>aaa attribute type linksec-policy must-secure</b>	(Optional) Specifies the AAA attribute type.
Step 9	<b>exit</b>	Returns to global configuration mode.
Step 10	<b>username</b> <i>name</i> <b>aaa attribute list</b> <i>name</i>	(Optional) Specifies the AAA attribute list for the user ID.
Step 11	<b>end</b>	Returns to privileged EXEC mode.

## Configuring Enrollment using SCEP

Simple Certificate Enrollment Protocol (SCEP) is a Cisco-developed enrollment protocol that uses HTTP to communicate with the certificate authority (CA) or registration authority (RA). SCEP is the most commonly used method for sending and receiving requests and certificates.

### Procedure

	Command or Action	Purpose
Step 1	<b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
Step 2	<b>configure terminal</b>	Enters global configuration mode.
Step 3	<b>crypto pki trustpoint</b> <i>server name</i>	Declares the trustpoint and a given name and enters ca-trustpoint configuration mode.

	Command or Action	Purpose
<b>Step 4</b>	<b>enrollment url</b> <i>url name pem</i>	<p>Specifies the URL of the CA on which your device should send certificate requests.</p> <p>An IPv6 address can be added in the URL enclosed in brackets. For example: http://[2001:DB8:1:1::1]:80.</p> <p>The pem keyword adds privacy-enhanced mail (PEM) boundaries to the certificate request.</p>
<b>Step 5</b>	<b>rsakeypair</b> <i>label</i>	<p>Specifies which key pair to associate with the certificate.</p> <p><b>Note</b> The <b>rsakeypair</b> name must match the trust-point name.</p>
<b>Step 6</b>	<b>serial-number</b> <b>none</b>	The <b>none</b> keyword specifies that a serial number will not be included in the certificate request.
<b>Step 7</b>	<b>ip-address</b> <b>none</b>	The <b>none</b> keyword specifies that no IP address should be included in the certificate request.
<b>Step 8</b>	<b>revocation-check</b> <b>crl</b>	Specifies CRL as the method to ensure that the certificate of a peer has not been revoked.
<b>Step 9</b>	<b>auto-enroll</b> <i>percent regenerate</i>	<p>Enables auto-enrollment, allowing the client to automatically request a rollover certificate from the CA.</p> <p>If auto-enrollment is not enabled, the client must be manually re-enrolled in your PKI upon certificate expiration.</p> <p>By default, only the Domain Name System (DNS) name of the device is included in the certificate.</p> <p>Use the percent argument to specify that a new certificate will be requested after the percentage of the lifetime of the current certificate is reached.</p> <p>Use the regenerate keyword to generate a new key for the certificate even if a named key already exists.</p> <p>If the key pair being rolled over is exportable, the new key pair will also be exportable. The following comment will appear in the trustpoint configuration to indicate whether the key pair is exportable: “! RSA key pair associated with trustpoint is exportable.”</p>

	Command or Action	Purpose
		It is recommended that a new key pair be generated for security reasons.
<b>Step 10</b>	<b>crypto pki authenticate</b> <i>name</i>	Retrieves the CA certificate and authenticates it.
<b>Step 11</b>	<b>exit</b>	Exits global configuration mode.
<b>Step 12</b>	<b>show crypto pki certificate</b> <i>trustpoint name</i>	Displays information about the certificate for the trust point.

## Configuring Enrollment Manually

If your CA does not support SCEP or if a network connection between the router and CA is not possible. Perform the following task to set up manual certificate enrollment:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>crypto pki trustpoint</b> <i>server name</i>	Declares the trustpoint and a given name and enters ca-trustpoint configuration mode.
<b>Step 4</b>	<b>enrollment url</b> <i>url name pem</i>	Specifies the URL of the CA on which your device should send certificate requests.  An IPv6 address can be added in the URL enclosed in brackets. For example: http://[2001:DB8:1:1::1]:80.  The pem keyword adds privacy-enhanced mail (PEM) boundaries to the certificate request.
<b>Step 5</b>	<b>rsa</b> <i>keypair label</i>	Specifies which key pair to associate with the certificate.
<b>Step 6</b>	<b>serial-number</b> <i>none</i>	The <b>none</b> keyword specifies that a serial number will not be included in the certificate request.
<b>Step 7</b>	<b>ip-address</b> <i>none</i>	The <b>none</b> keyword specifies that no IP address should be included in the certificate request.
<b>Step 8</b>	<b>revocation-check</b> <i>crl</i>	Specifies CRL as the method to ensure that the certificate of a peer has not been revoked.
<b>Step 9</b>	<b>exit</b>	Exits Global Configuration mode.

	Command or Action	Purpose
<b>Step 10</b>	<code>crypto pki authenticate <i>name</i></code>	Retrieves the CA certificate and authenticates it.
<b>Step 11</b>	<code>crypto pki enroll <i>name</i></code>	<p>Generates certificate request and displays the request for copying and pasting into the certificate server.</p> <p>Enter enrollment information when you are prompted. For example, specify whether to include the device FQDN and IP address in the certificate request.</p> <p>You are also given the choice about displaying the certificate request to the console terminal.</p> <p>The base-64 encoded certificate with or without PEM headers as requested is displayed.</p>
<b>Step 12</b>	<code>crypto pki import <i>name certificate</i></code>	<p>Imports a certificate via TFTP at the console terminal, which retrieves the granted certificate.</p> <p>The device attempts to retrieve the granted certificate via TFTP using the same filename used to send the request, except the extension is changed from “.req” to “.crt”. For usage key certificates, the extensions “-sign.crt” and “-encr.crt” are used.</p> <p>The device parses the received files, verifies the certificates, and inserts the certificates into the internal certificate database on the switch.</p> <p><b>Note</b> Some CAs ignore the usage key information in the certificate request and issue general purpose usage certificates. If your CA ignores the usage key information in the certificate request, only import the general purpose certificate. The router will not use one of the two key pairs generated.</p>
<b>Step 13</b>	<code>exit</code>	Exits Global Configuration mode.
<b>Step 14</b>	<code>show crypto pki certificate <i>trustpoint name</i></code>	Displays information about the certificate for the trust point.
<b>Step 15</b>	<code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring EAP-TLS Profile and 802.1x Credentials

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>enable</code>	Enables privileged EXEC mode. • Enter your password if prompted.
<b>Step 2</b>	<code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<code>eap profile <i>profile-name</i></code>	Configures EAP profile and enters EAP profile configuration mode.
<b>Step 4</b>	<code>method tls</code>	Enables EAP-TLS method on the device.
<b>Step 5</b>	<code>pki-trustpoint <i>name</i></code>	Sets the default PKI trustpoint.
<b>Step 6</b>	<code>exit</code>	Returns to global configuration mode.
<b>Step 7</b>	<code>dot1x credentials <i>profile-name</i></code>	Configures 802.1x credentials profile and enters dot1x credentials configuration mode.
<b>Step 8</b>	<code>username <i>username</i></code>	Sets the authentication user ID.
<b>Step 9</b>	<code>pki-trustpoint <i>name</i></code>	Sets the default PKI trustpoint.
<b>Step 10</b>	<code>end</code>	Returns to privileged EXEC mode.

## Applying the 802.1x MKA MACsec Configuration on Interfaces

To apply MKA MACsec using EAP-TLS to interfaces, perform the following task:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>enable</code>	Enables privileged EXEC mode. • Enter your password if prompted.
<b>Step 2</b>	<code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<code>interface <i>interface-id</i></code>	Identifies the MACsec interface, and enter interface configuration mode. The interface must be a physical interface.
<b>Step 4</b>	<code>macsec</code>	Enables MACsec on the interface.
<b>Step 5</b>	<code>authentication periodic</code>	Enables reauthentication for this port.
<b>Step 6</b>	<code>authentication timer reauthenticate interval</code>	Sets the reauthentication interval.





The **show macsec status interface *interface-id*** displays MACsec status information for the given interface.

```
Device# show macsec status interface te0/1/2
```

```
Capabilities:
Ciphers Supported:      GCM-AES-128 GCM-AES-256
Cipher:                GCM-AES-128
Confidentiality Offset: 0
Replay Window:        64
Delay Protect Enable:  FALSE
Access Control:       must-secure

Transmit SC:
  SCI:                74A2E6254C220012
  Transmitting:      TRUE
Transmit SA:
  Next PN:           412
  Delay Protect AN/nextPN: 99/0

Receive SC:
  SCI:                74A2E62544130013
  Receiving:         TRUE
Receive SA:
  Next PN:           64
  AN:                 0
  Delay Protect AN/LPN: 0/0
```

The **show access-session interface *interface-id* details** displays detailed information about the access session for the given interface.

```
Device# show access-session interface tel/0/1 details
```

```
Interface: TenGigabitEthernet1/0/1
  IIF-ID: 0x17298FCD
  MAC Address: f8a5.c592.13e4
  IPv6 Address: Unknown
  IPv4 Address: Unknown
  User-Name: DOT1XCRED
  Status: Authorized
  Domain: DATA
  Oper host mode: multi-host
  Oper control dir: both
  Session timeout: N/A
  Common Session ID: 00000000000000BB72E8AFA
  Acct Session ID: Unknown
  Handle: 0xc3000001
  Current Policy: MUSTS_1

Local Policies:
  Security Policy: Must Secure
  Security Status: Link Secured

Server Policies:

Method status list:
  Method      State
  dot1xSup    Authc Success
  dot1x       Authc Success
```

# Cisco TrustSec Overview

The table below lists the TrustSec features to be eventually implemented on TrustSec-enabled Cisco switches. Successive general availability releases of TrustSec will expand the number of switches supported and the number of TrustSec features supported per switch.

Cisco TrustSec Feature	Description
802.1AE Tagging (MACsec)	<p>Protocol for IEEE 802.1AE-based wire-rate hop-to-hop Layer 2 encryption.</p> <p>Between MACsec-capable devices, packets are encrypted on egress from the transmitting device, decrypted on ingress to the receiving device, and in the clear within the devices.</p> <p>This feature is only available between TrustSec hardware-capable devices.</p>
Endpoint Admission Control (EAC)	<p>EAC is an authentication process for an endpoint user or a device connecting to the TrustSec domain. Usually EAC takes place at the access level switch. Successful authentication and authorization in the EAC process results in Security Group Tag assignment for the user or device. Currently EAC can be 802.1X, MAC Authentication Bypass (MAB), and Web Authentication Proxy (WebAuth).</p>
Network Device Admission Control (NDAC)	<p>NDAC is an authentication process where each network device in the TrustSec domain can verify the credentials and trustworthiness of its peer device. NDAC utilizes an authentication framework based on IEEE 802.1X port-based authentication and uses EAP-FAST as its EAP method. Successful authentication and authorization in NDAC process results in Security Association Protocol negotiation for IEEE 802.1AE encryption.</p>
Security Association Protocol (SAP)	<p>After NDAC authentication, the Security Association Protocol (SAP) automatically negotiates keys and the cipher suite for subsequent MACSec link encryption between TrustSec peers. SAP is defined in IEEE 802.11i.</p>
Security Group Tag (SGT)	<p>An SGT is a 16-bit single label indicating the security classification of a source in the TrustSec domain. It is appended to an Ethernet frame or an IP packet.</p>

Cisco TrustSec Feature	Description
SGT Exchange Protocol (SXP)	Security Group Tag Exchange Protocol (SXP). With SXP, devices that are not TrustSec-hardware-capable can receive SGT attributes for authenticated users and devices from the Cisco Identity Services Engine (ISE) or the Cisco Secure Access Control System (ACS). The devices can then forward a sourceIP-to-SGT binding to a TrustSec-hardware-capable device will tag the source traffic for SGACL enforcement.

When both ends of a link support 802.1AE MACsec, SAP negotiation occurs. An EAPOL-key exchange occurs between the supplicant and the authenticator to negotiate a cipher suite, exchange security parameters, and manage keys. Successful completion of these tasks results in the establishment of a security association (SA).

Depending on your software version and licensing and link hardware support, SAP negotiation can use one of these modes of operation:

- Galois Counter Mode (GCM)—authentication and encryption
- GCM authentication (GMAC)— GCM authentication, no encryption
- No Encapsulation—no encapsulation (clear text)
- Null—encapsulation, no authentication or encryption

## Configuring Cisco TrustSec MACsec

### Configuring Cisco TrustSec Switch-to-Switch Link Security in Manual Mode

#### Before you begin

When manually configuring Cisco TrustSec on an interface, consider these usage guidelines and restrictions:

- If no SAP parameters are defined, Cisco TrustSec encapsulation or encryption is not performed.
- If you select GCM as the SAP operating mode, you must have a MACsec Encryption software license from Cisco. If you select GCM without the required license, the interface is forced to a link-down state.
- These protection levels are supported when you configure SAP pairwise master key (sap pmk):
  - SAP is not configured—no protection.
  - **sap mode-list gcm-encrypt gmac no-encap**—protection desirable but not mandatory.
  - **sap mode-list gcm-encrypt gmac**—confidentiality preferred and integrity required. The protection is selected by the supplicant according to supplicant preference.
  - **sap mode-list gmac**—integrity only.
  - **sap mode-list gcm-encrypt**—confidentiality required.
  - **sap mode-list gmac gcm-encrypt**—integrity required and preferred, confidentiality optional.

- When CTS is configured on an interface and the System MTU is set to a value greater than 9191, the resulting packet size is limited to 9190.
- Before changing the configuration from MKA to Cisco TrustSec SAP and vice versa, we recommend that you remove the interface configuration.

Beginning in privileged EXEC mode, follow these steps to manually configure Cisco TrustSec on an interface to another Cisco TrustSec device:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Switch# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b>  <b>Example:</b> Switch(config)# <b>interface</b> <b>tengigabitethernet 1/1/2</b>	<b>Note</b> Enters interface configuration mode.
<b>Step 3</b>	<b>cts manual</b>  <b>Example:</b> Switch(config-if)# <b>cts manual</b>	Enters Cisco TrustSec manual configuration mode.
<b>Step 4</b>	<b>sap pmk key [mode-list mode1 [mode2 [mode3 [mode4] ] ] ]</b>  <b>Example:</b> Switch(config-if-cts-manual)# <b>sap pmk</b> <b>1234abcdef mode-list</b> <b>gcm-encrypt null no-encap</b>	(Optional) Configures the SAP pairwise master key (PMK) and operation mode. SAP is disabled by default in Cisco TrustSec manual mode.  • <i>key</i> —A hexadecimal value with an even number of characters and a maximum length of 32 characters.  The SAP operation mode options:  • <b>gcm-encrypt</b> —Authentication and encryption  <b>Note</b> Select this mode for MACsec authentication and encryption if your software license supports MACsec encryption.  • <b>gmac</b> —Authentication, no encryption  • <b>no-encap</b> —No encapsulation  • <b>null</b> —Encapsulation, no authentication or encryption

	Command or Action	Purpose
		<b>Note</b> If the interface is not capable of data link encryption, <b>no-encap</b> is the default and the only available SAP operating mode. SGT is not supported.
<b>Step 5</b>	<b>no propagate sgt</b> <b>Example:</b> Switch(config-if-cts-manual)# <b>no propagate sgt</b>	Use the <b>no</b> form of this command when the peer is incapable of processing a SGT. The <b>no propagate sgt</b> command prevents the interface from transmitting the SGT to the peer.
<b>Step 6</b>	<b>exit</b> <b>Example:</b> Switch(config-if-cts-manual)# <b>exit</b>	Exits Cisco TrustSec 802.1x interface configuration mode.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Switch(config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show cts interface</b> [ <i>interface-id</i>   <b>brief</b>   <b>summary</b> ]	(Optional) Verify the configuration by displaying TrustSec-related interface characteristics.

**Example**

This example shows how to configure Cisco TrustSec authentication in manual mode on an interface:

```
Switch# configure terminal
Switch(config)# interface tengigabitethernet 1/1/2
Switch(config-if)# cts manual
Switch(config-if-cts-manual)# sap pmk 1234abcdef mode-list gcm-encrypt null no-encap
Switch(config-if-cts-manual)# no propagate sgt
Switch(config-if-cts-manual)# exit
Switch(config-if)# end
```

## Configuration Examples

### Configuring MACsec on an Interface

Follow these steps to configure MACsec on an interface with one MACsec session for voice and one for data:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Switch>enable	Enables privileged EXEC mode. Enter the password if prompted.
<b>Step 2</b>	<b>configureterminal</b> <b>Example:</b> Switch>configure terminal	Enters the global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>interface-id</i>	Identify the MACsec interface, and enter interface configuration mode. The interface must be a physical interface.
<b>Step 4</b>	<b>switchport access vlan</b> <i>vlan-id</i>	Configure the access VLAN for the port.
<b>Step 5</b>	<b>switchport mode access</b>	Configure the interface as an access port.
<b>Step 6</b>	<b>macsec</b>	Enable 802.1ae MACsec on the interface. The macsec command enables MKA MACsec on switch-to-host links (downlink ports) only.
<b>Step 7</b>	<b>authentication event linksec fail action authorize vlan</b> <i>vlan-id</i>	(Optional) Specify that the switch processes authentication link-security failures resulting from unrecognized user credentials by authorizing a restricted VLAN on the port after a failed authentication attempt.
<b>Step 8</b>	<b>authentication host-mode multi-domain</b>	Configure authentication manager mode on the port to allow both a host and a voice device to be authenticated on the 802.1x-authorized port. If not configured, the default host mode is single.
<b>Step 9</b>	<b>authentication linksec policy must-secure</b>	Set the LinkSec security policy to secure the session with MACsec if the peer is available. If not set, the default is <i>should secure</i> .
<b>Step 10</b>	<b>authentication port-control auto</b>	Enable 802.1x authentication on the port. The port changes to the authorized or unauthorized state based on the authentication exchange between the switch and the client.
<b>Step 11</b>	<b>authentication periodic</b>	Enable or Disable Reauthentication for this port .
<b>Step 12</b>	<b>authentication timer reauthenticate</b>	Enter a value between 1 and 65535 (in seconds). Obtains re-authentication timeout value from the server. Default re-authentication time is 3600 seconds.

	Command or Action	Purpose
Step 13	<b>authentication violation protect</b>	Configure the port to drop unexpected incoming MAC addresses when a new device connects to a port or when a device connects to a port after the maximum number of devices are connected to that port. If not configured, the default is to shut down the port.
Step 14	<b>mka policy</b> <i>policy name</i>	Apply an existing MKA protocol policy to the interface, and enable MKA on the interface. If no MKA policy was configured (by entering the <b>mka policy</b> global configuration command).
Step 15	<b>dot1x pae authenticator</b>	Configure the port as an 802.1x port access entity (PAE) authenticator.
Step 16	<b>spanning-tree portfast</b>	Enable spanning tree Port Fast on the interface in all its associated VLANs. When Port Fast feature is enabled, the interface changes directly from a blocking state to a forwarding state without making the intermediate spanning-tree state changes
Step 17	<b>end</b>  <b>Example:</b> Switch(config)# <b>end</b>	Returns to privileged EXEC mode.
Step 18	<b>show authentication session interface</b> <i>interface-id</i>	Verify the authorized session security status.
Step 19	<b>show authentication session interface</b> <i>interface-id</i> details	Verify the details of the security status of the authorized session.
Step 20	<b>show macsec interface</b> <i>interface-id</i>	Verify MacSec status on the interface.
Step 21	<b>show mka sessions</b>	Verify the established mka sessions.
Step 22	<b>copy running-config startup-config</b>  <b>Example:</b> Switch# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuration Examples for MACsec MKA using EAP-TLS

### Example: Enrolling the Certificate

```
Configure Crypto PKI Trustpoint:
crypto pki trustpoint POLESTAR-IOS-CA
enrollment terminal
```



```

subject-name CN=ASR1000x1@polestar.com, C=IN, ST=KA, OU=ENG,O=Polestar
revocation-check none
rsaкеypair mkaioscarsa
storage nvram:
!

```

**Manual Installation of Root CA certificate:**

```
crypto pki authenticate POLESTAR-IOS-CA
```

## Example: Enabling 802.1x Authentication and AAA Configuration

```

aaa new-model
dot1x system-auth-control
radius server ISE
address ipv4 <ISE ipv4 address> auth-port 1645 acct-port 1646
automate-tester username dummy
key dummy123
radius-server deadtime 2
!
aaa group server radius ISEGRP
server name ISE
!
aaa authentication dot1x default group ISEGRP
aaa authorization network default group ISEGRP

```

## Example: Configuring EAP-TLS Profile and 802.1X Credentials

```

eap profile EAPTLS-PROF-IOSCA
method tls
pki-trustpoint POLESTAR-IOS-CA
!

dot1x credentials EAPTLSCRED-IOSCA
username asr1000@polestar.company.com
pki-trustpoint POLESTAR-IOS-CA
!

```

## Example: Applying 802.1X, PKI, and MACsec Configuration on the Interface

```

interface TenGigabitEthernet0/1
macsec network-link
authentication periodic
authentication timer reauthenticate <reauthentication interval>
access-session host-mode multi-host
access-session closed
access-session port-control auto
dot1x pae both
dot1x credentials EAPTLSCRED-IOSCA
dot1x supplicant eap profile EAPTLS-PROF-IOSCA
service-policy type control subscriber DOT1X_POLICY_RADIUS

```

## Example: Cisco TrustSec Switch-to-Switch Link Security Configuration

This example shows the configuration necessary for a seed and non-seed device for Cisco TrustSec switch-to-switch security. You must configure the AAA and RADIUS for link security. In this example, ACS-1 through ACS-3 can be any server names and cts-radius is the Cisco TrustSec server.

Seed Device Configuration:

```
Switch(config)#aaa new-model
Switch(config)#radius server ACS-1
Switch(config-radius-server)#address ipv4 10.5.120.12 auth-port 1812 acct-port
1813
Switch(config-radius-server)#pac key cisco123
Switch(config-radius-server)#exit
Switch(config)#radius server ACS-2
Switch(config-radius-server)#address ipv4 10.5.120.14 auth-port 1812 acct-port
1813
Switch(config-radius-server)#pac key cisco123
Switch(config-radius-server)#exit
Switch(config)#radius server ACS-3
Switch(config-radius-server)#address ipv4 10.5.120.15 auth-port 1812 acct-port
1813
Switch(config-radius-server)#pac key cisco123
Switch(config-radius-server)#exit
Switch(config)#aaa group server radius cts-radius
Switch(config-sg-radius)#server name ACS-1
Switch(config-sg-radius)#server name ACS-2
Switch(config-sg-radius)#server name ACS-3
Switch(config-sg-radius)#exit
Switch(config)#aaa authentication login default none
Switch(config)#aaa authentication dot1x default group cts-radius
Switch(config)#aaa authorization network cts-radius group cts-radius
Switch(config)#aaa session-id common
Switch(config)#cts authorization list cts-radius
Switch(config)#dot1x system-auth-control

Switch(config)#interface gil/1/2
Switch(config-if)#switchport mode trunk
Switch(config-if)#cts manual
Switch(config-if-cts-manual)#sap pmk 0 abcd mode-list gcm-encrypt gmac

Switch(config-if-cts-manual)#exit
Switch(config-if)#exit

Switch(config)#interface gil/1/4
Switch(config-if)#switchport mode trunk
Switch(config-if)#cts manual
Switch(config-if-cts-manual)#sap pmk 033445AABBCCDDEEFF mode-list gcm-encrypt
gmac
Switch(config-if-cts-manual)#no propagate sgt
Switch(config-if-cts-manual)#exit
Switch(config-if)#exit
```

```
Switch(config)#radius-server vsa send authentication
Switch(config)#end
Switch#cts credentials id cts-36 password trustsec123
```

Non-Seed Device:

```
Switch(config)#aaa new-model
Switch(config)#aaa session-id common
Switch(config)#dot1x system-auth-control

Switch(config)#interface gil1/1/2
Switch(config-if)#switchport mode trunk
Switch(config-if)#shutdown
Switch(config-if)#cts manual
Switch(config-if-cts-manual)#sap pmk 0 abcd mode-list gcm-encrypt gmac
Switch(config-if-cts-manual)#exit
Switch(config-if)#exit

Switch(config)#interface gil1/1/4
Switch(config-if)#switchport mode trunk
Switch(config-if)#shutdown
Switch(config-if)#cts manual
Switch(config-if-cts-manual)#sap pmk 033445AABCCDDEEFF mode-list gcm-encrypt
gmac
Switch(config-if-cts-manual)#no propagate sgt
Switch(config-if-cts-manual)#exit
Switch(config-if)#exit

Switch(config)#radius-server vsa send authentication
Switch(config)#cts credentials id cts-72 password trustsec123
Switch(config)#end
```





## CHAPTER 98

# Configuring RADIUS

- [Finding Feature Information, on page 1783](#)
- [Prerequisites for Configuring RADIUS, on page 1783](#)
- [Restrictions for Configuring RADIUS, on page 1784](#)
- [Information about RADIUS, on page 1785](#)
- [How to Configure RADIUS, on page 1808](#)
- [Monitoring CoA Functionality, on page 1824](#)
- [Additional References for Configuring Secure Shell, on page 1824](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Configuring RADIUS

This section lists the prerequisites for controlling Device access with RADIUS.

General:

- RADIUS and Authentication, Authorization, and Accounting (AAA) must be enabled to use any of the configuration commands in this chapter.
- RADIUS is facilitated through AAA and can be enabled only through AAA commands.
- Use the **aaa new-model** global configuration command to enable AAA.
- Use the **aaa authentication** global configuration command to define method lists for RADIUS authentication.
- Use **line** and **interface** commands to enable the defined method lists to be used.

- At a minimum, you must identify the host or hosts that run the RADIUS server software and define the method lists for RADIUS authentication. You can optionally define method lists for RADIUS authorization and accounting.
- You should have access to and should configure a RADIUS server before configuring RADIUS features on your Device.
- The RADIUS host is normally a multiuser system running RADIUS server software from Cisco (Cisco Secure Access Control Server Version 3.0), Livingston, Merit, Microsoft, or another software provider. For more information, see the RADIUS server documentation.
- To use the Change-of-Authorization (CoA) interface, a session must already exist on the switch. CoA can be used to identify a session and enforce a disconnect request. The update affects only the specified session.
- A redundant connection between a switch stack and the RADIUS server is recommended. This is to help ensure that the RADIUS server remains accessible in case one of the connected stack members is removed from the switch stack.

For RADIUS operation:

- Users must first successfully complete RADIUS authentication before proceeding to RADIUS authorization, if it is enabled.

#### Related Topics

[RADIUS and Switch Access](#), on page 1785

[RADIUS Operation](#), on page 1786

## Restrictions for Configuring RADIUS

This topic covers restrictions for controlling Device access with RADIUS.

General:

- To prevent a lapse in security, you cannot configure RADIUS through a network management application.

RADIUS is not suitable in the following network security situations:

- Multiprotocol access environments. RADIUS does not support AppleTalk Remote Access (ARA), NetBIOS Frame Control Protocol (NBFCP), NetWare Asynchronous Services Interface (NASI), or X.25 PAD connections.
- Switch-to-switch or router-to-router situations. RADIUS does not provide two-way authentication. RADIUS can be used to authenticate from one device to a non-Cisco device if the non-Cisco device requires authentication.
- Networks using a variety of services. RADIUS generally binds a user to one service model.

#### Related Topics

[RADIUS Overview](#), on page 1785

# Information about RADIUS

## RADIUS and Switch Access

This section describes how to enable and configure RADIUS. RADIUS provides detailed accounting information and flexible administrative control over the authentication and authorization processes.

### Related Topics

[Prerequisites for Configuring RADIUS](#), on page 1783

[Configuring the Switch for Local Authentication and Authorization](#), on page 1839

[SSH Servers, Integrated Clients, and Supported Versions](#), on page 1845

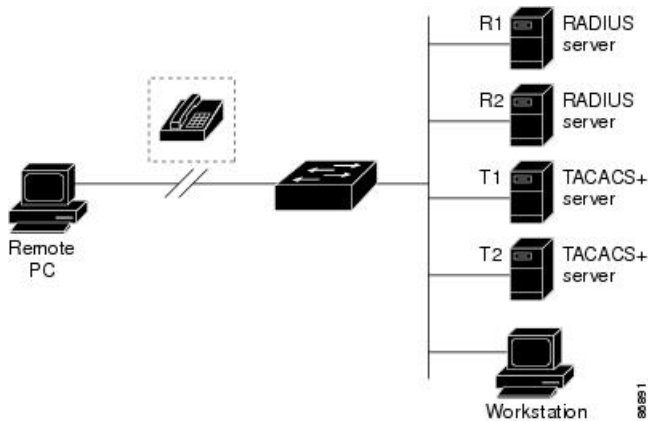
## RADIUS Overview

RADIUS is a distributed client/server system that secures networks against unauthorized access. RADIUS clients run on supported Cisco routers and switches. Clients send authentication requests to a central RADIUS server, which contains all user authentication and network service access information.

Use RADIUS in these network environments that require access security:

- Networks with multiple-vendor access servers, each supporting RADIUS. For example, access servers from several vendors use a single RADIUS server-based security database. In an IP-based network with multiple vendors' access servers, dial-in users are authenticated through a RADIUS server that has been customized to work with the Kerberos security system.
- Turnkey network security environments in which applications support the RADIUS protocol, such as in an access environment that uses a *smart card* access control system. In one case, RADIUS has been used with Enigma's security cards to validate users and to grant access to network resources.
- Networks already using RADIUS. You can add a Cisco Device containing a RADIUS client to the network. This might be the first step when you make a transition to a TACACS+ server. See Figure 2: Transitioning from RADIUS to TACACS+ Services below.
- Network in which the user must only access a single service. Using RADIUS, you can control user access to a single host, to a single utility such as Telnet, or to the network through a protocol such as IEEE 802.1x. For more information about this protocol, see Chapter 11, "Configuring IEEE 802.1x Port-Based Authentication."
- Networks that require resource accounting. You can use RADIUS accounting independently of RADIUS authentication or authorization. The RADIUS accounting functions allow data to be sent at the start and end of services, showing the amount of resources (such as time, packets, bytes, and so forth) used during the session. An Internet service provider might use a freeware-based version of RADIUS access control and accounting software to meet special security and billing needs.

Figure 108: Transitioning from RADIUS to TACACS+ Services



### Related Topics

[Restrictions for Configuring RADIUS](#), on page 1784

## RADIUS Operation

When a user attempts to log in and authenticate to a Device that is access controlled by a RADIUS server, these events occur:

1. The user is prompted to enter a username and password.
2. The username and encrypted password are sent over the network to the RADIUS server.
3. The user receives one of the following responses from the RADIUS server:
  - ACCEPT—The user is authenticated.
  - REJECT—The user is either not authenticated and is prompted to re-enter the username and password, or access is denied.
  - CHALLENGE—A challenge requires additional data from the user.
  - CHALLENGE PASSWORD—A response requests the user to select a new password.

The ACCEPT or REJECT response is bundled with additional data that is used for privileged EXEC or network authorization. The additional data included with the ACCEPT or REJECT packets includes these items:

- Telnet, SSH, rlogin, or privileged EXEC services
- Connection parameters, including the host or client IP address, access list, and user timeouts

### Related Topics

[Prerequisites for Configuring RADIUS](#), on page 1783



## RADIUS Change of Authorization

The RADIUS Change of Authorization (CoA) provides a mechanism to change the attributes of an authentication, authorization, and accounting (AAA) session after it is authenticated. When a policy changes for a user or user group in AAA, administrators can send RADIUS CoA packets from the AAA server such as a Cisco Secure Access Control Server (ACS) to reinitialize authentication and apply the new policy. This section provides an overview of the RADIUS interface including available primitives and how they are used during a CoA.

- Change-of-Authorization Requests
- CoA Request Response Code
- CoA Request Commands
- Session Reauthentication
- Stacking Guidelines for Session Termination

A standard RADIUS interface is typically used in a pulled model where the request originates from a network attached device and the response come from the queried servers. Catalyst support the RADIUS CoA extensions defined in RFC 5176 that are typically used in a pushed model and allow for the dynamic reconfiguring of sessions from external AAA or policy servers.

The supports these per-session CoA requests:

- Session reauthentication
- Session termination
- Session termination with port shutdown
- Session termination with port bounce

This feature is integrated with Cisco Secure Access Control Server (ACS) 5.1.

The RADIUS interface is enabled by default on Catalyst . However, some basic configuration is required for the following attributes:

- Security and Password—refer to the “Preventing Unauthorized Access to Your Switch” section in this guide.
- Accounting—refer to the “Starting RADIUS Accounting” section in the Configuring Switch-Based Authentication chapter in this guide.

Cisco IOS software supports the RADIUS CoA extensions defined in RFC 5176 that are typically used in a push model to allow the dynamic reconfiguring of sessions from external AAA or policy servers. Per-session CoA requests are supported for session identification, session termination, host reauthentication, port shutdown, and port bounce. This model comprises one request (CoA-Request) and two possible response codes:

- CoA acknowledgement (ACK) [CoA-ACK]
- CoA nonacknowledgement (NAK) [CoA-NAK]

The request is initiated from a CoA client (typically a AAA or policy server) and directed to the device that acts as a listener.

The table below shows the RADIUS CoA commands and vendor-specific attributes (VSAs) supported by Identity-Based Networking Services. All CoA commands must include the session identifier between the device and the CoA client.

**Table 130: RADIUS CoA Commands Supported by Identity-Based Networking Services**

CoA Command	Cisco VSA
Activate service	Cisco:Avpair="subscriber:command=activate-service" Cisco:Avpair="subscriber:service-name=<service-name>" Cisco:Avpair="subscriber:precedence=<precedence-number>" Cisco:Avpair="subscriber:activation-mode=replace-all"
Deactivate service	Cisco:Avpair="subscriber:command=deactivate-service" Cisco:Avpair="subscriber:service-name=<service-name>"
Bounce host port	Cisco:Avpair="subscriber:command=bounce-host-port"
Disable host port	Cisco:Avpair="subscriber:command=disable-host-port"
Session query	Cisco:Avpair="subscriber:command=session-query"
Session reauthenticate	Cisco:Avpair="subscriber:command=reauthenticate" Cisco:Avpair="subscriber:reauthenticate-type=last" or Cisco:Avpair="subscriber:reauthenticate-type=rerun"
Session terminate	This is a standard disconnect request and does not require a VSA.
Interface template	Cisco:AVpair="interface-template-name=<interfacetemplate>"

## Change-of-Authorization Requests

Change of Authorization (CoA) requests, as described in RFC 5176, are used in a push model to allow for session identification, host reauthentication, and session termination. The model is comprised of one request (CoA-Request) and two possible response codes:

- CoA acknowledgment (ACK) [CoA-ACK]
- CoA non-acknowledgment (NAK) [CoA-NAK]

The request is initiated from a CoA client (typically a RADIUS or policy server) and directed to the switch that acts as a listener.

### RFC 5176 Compliance

The Disconnect Request message, which is also referred to as Packet of Disconnect (POD), is supported by the switch for session termination.

This table shows the IETF attributes are supported for this feature.

**Table 131: Supported IETF Attributes**

Attribute Number	Attribute Name
24	State
31	Calling-Station-ID
44	Acct-Session-ID
80	Message-Authenticator
101	Error-Cause

This table shows the possible values for the Error-Cause attribute.

**Table 132: Error-Cause Values**

Value	Explanation
201	Residual Session Context Removed
202	Invalid EAP Packet (Ignored)
401	Unsupported Attribute
402	Missing Attribute
403	NAS Identification Mismatch
404	Invalid Request
405	Unsupported Service
406	Unsupported Extension
407	Invalid Attribute Value
501	Administratively Prohibited
502	Request Not Routable (Proxy)
503	Session Context Not Found
504	Session Context Not Removable
505	Other Proxy Processing Error
506	Resources Unavailable
507	Request Initiated
508	Multiple Session Selection Unsupported

## CoA Request Response Code

The CoA Request response code can be used to convey a command to the switch.

The packet format for a CoA Request Response code as defined in RFC 5176 consists of the following fields: Code, Identifier, Length, Authenticator, and Attributes in the Type:Length:Value (TLV) format. The Attributes field is used to carry Cisco vendor-specific attributes (VSAs).

### Related Topics

[CoA Request Commands](#), on page 1791

### Session Identification

For disconnect and CoA requests targeted at a particular session, the switch locates the session based on one or more of the following attributes:

- Acct-Session-Id (IETF attribute #44)
- Audit-Session-Id (Cisco VSA)
- Calling-Station-Id (IETF attribute #31 which contains the host MAC address)
- IPv6 Attributes, which can be one of the following:
  - Framed-IPv6-Prefix (IETF attribute #97) and Framed-Interface-Id (IETF attribute #96), which together create a full IPv6 address per RFC 3162
  - Framed-IPv6-Address
- Plain IP Address (IETF attribute #8)

Unless all session identification attributes included in the CoA message match the session, the switch returns a Disconnect-NAK or CoA-NAK with the “Invalid Attribute Value” error-code attribute.

If more than one session identification attribute is included in the message, all the attributes must match the session or the switch returns a Disconnect- negative acknowledgment (NAK) or CoA-NAK with the error code “Invalid Attribute Value.”

The packet format for a CoA Request code as defined in RFC 5176 consists of the fields: Code, Identifier, Length, Authenticator, and Attributes in Type:Length:Value (TLV) format.

```

      0           1           2           3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |      Code      | Identifier |                               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                               Authenticator                               |
  |                               |                                           |
  |                               |                                           |
  |                               |                                           |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  | Attributes ... |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  
```

The attributes field is used to carry Cisco vendor-specific attributes (VSAs).

For CoA requests targeted at a particular enforcement policy, the device returns a CoA-NAK with the error code “Invalid Attribute Value” if any of the above session identification attributes are included in the message.

**Related Topics**

- [CoA Disconnect-Request](#), on page 1792
- [CoA Request: Disable Host Port](#), on page 1792
- [CoA Request: Bounce-Port](#), on page 1793

**CoA ACK Response Code**

If the authorization state is changed successfully, a positive acknowledgment (ACK) is sent. The attributes returned within CoA ACK will vary based on the CoA Request and are discussed in individual CoA Commands.

**CoA NAK Response Code**

A negative acknowledgment (NAK) indicates a failure to change the authorization state and can include attributes that indicate the reason for the failure. Use **show** commands to verify a successful CoA.

**CoA Request Commands**

*Table 133: CoA Commands Supported on the*

Command	Cisco VSA
<sup>8</sup>	
Reauthenticate host	Cisco:Avpair="subscriber:command=reauthenticate"
Terminate session	This is a standard disconnect request that does not require a VSA.
Bounce host port	Cisco:Avpair="subscriber:command=bounce-host-port"
Disable host port	Cisco:Avpair="subscriber:command=disable-host-port"

<sup>8</sup> All CoA commands must include the session identifier between the `&` and the CoA client.

**Related Topics**

- [CoA Request Response Code](#), on page 1790

**Session Reauthentication**

The AAA server typically generates a session reauthentication request when a host with an unknown identity or posture joins the network and is associated with a restricted access authorization profile (such as a guest VLAN). A reauthentication request allows the host to be placed in the appropriate authorization group when its credentials are known.

To initiate session authentication, the AAA server sends a standard CoA-Request message which contains a Cisco VSA in this form: *Cisco:Avpair="subscriber:command=reauthenticate"* and one or more session identification attributes.

The current session state determines the switch response to the message. If the session is currently authenticated by IEEE 802.1x, the switch responds by sending an EAPoL (Extensible Authentication Protocol over Lan) -RequestId message to the server.

If the session is currently authenticated by MAC authentication bypass (MAB), the switch sends an access-request to the server, passing the same identity attributes used for the initial successful authentication.

If session authentication is in progress when the switch receives the command, the switch terminates the process, and restarts the authentication sequence, starting with the method configured to be attempted first.

If the session is not yet authorized, or is authorized via guest VLAN, or critical VLAN, or similar policies, the reauthentication message restarts the access control methods, beginning with the method configured to be attempted first. The current authorization of the session is maintained until the reauthentication leads to a different authorization result.

### Session Reauthentication in a Switch Stack

When a switch stack receives a session reauthentication message:

- It checkpoints the need for a re-authentication before returning an acknowledgment (ACK).
- It initiates reauthentication for the appropriate session.
- If authentication completes with either success or failure, the signal that triggered the reauthentication is removed from the stack member.
- If the stack master fails before authentication completes, reauthentication is initiated after stack master switch-over based on the original command (which is subsequently removed).
- If the stack master fails before sending an ACK, the new stack master treats the re-transmitted command as a new command.

### Session Termination

There are three types of CoA requests that can trigger session termination. A CoA Disconnect-Request terminates the session, without disabling the host port. This command causes re-initialization of the authenticator state machine for the specified host, but does not restrict that host access to the network.

To restrict a host's access to the network, use a CoA Request with the `Cisco:Avpair="subscriber:command=disable-host-port"` VSA. This command is useful when a host is known to be causing problems on the network, and you need to immediately block network access for the host. When you want to restore network access on the port, re-enable it using a non-RADIUS mechanism.

When a device with no supplicant, such as a printer, needs to acquire a new IP address (for example, after a VLAN change), terminate the session on the host port with port-bounce (temporarily disable and then re-enable the port).

### CoA Disconnect-Request

This command is a standard Disconnect-Request. If the session cannot be located, the switch returns a Disconnect-NAK message with the "Session Context Not Found" error-code attribute. If the session is located, the switch terminates the session. After the session has been completely removed, the switch returns a Disconnect-ACK.

If the switch fails-over to a standby switch before returning a Disconnect-ACK to the client, the process is repeated on the new active switch when the request is re-sent from the client. If the session is not found following re-sending, a Disconnect-ACK is sent with the "Session Context Not Found" error-code attribute.

#### Related Topics

[Session Identification](#), on page 1790

### CoA Request: Disable Host Port

The RADIUS server CoA disable port command administratively shuts down the authentication port that is hosting a session, resulting in session termination. This command is useful when a host is known to cause problems on the network and network access needs to be immediately blocked for the host. To restore network

access on the port, reenable it using a non-RADIUS mechanism. This command is carried in a standard CoA-Request message that has this new vendor-specific attribute (VSA):

```
Cisco:Avpair="subscriber:command=disable-host-port"
```

Because this command is session-oriented, it must be accompanied by one or more of the session identification attributes described in the “Session Identification” section. If the session cannot be located, the switch returns a CoA-NAK message with the “Session Context Not Found” error-code attribute. If the session is located, the switch disables the hosting port and returns a CoA-ACK message.

If the switch fails before returning a CoA-ACK to the client, the process is repeated on the new active switch when the request is re-sent from the client. If the switch fails after returning a CoA-ACK message to the client but before the operation has completed, the operation is restarted on the new active switch.



**Note** A Disconnect-Request failure following command re-sending could be the result of either a successful session termination before change-over (if the Disconnect-ACK was not sent) or a session termination by other means (for example, a link failure) that occurred after the original command was issued and before the standby switch became active.

#### Related Topics

[Session Identification](#), on page 1790

### CoA Request: Bounce-Port

A RADIUS server CoA bounce port sent from a RADIUS server can cause a link flap on an authentication port, which triggers DHCP renegotiation from one or more hosts connected to this port. This incident can occur when there is a VLAN change and the endpoint is a device (such as a printer) that does not have a mechanism to detect a change on this authentication port. The CoA bounce port is carried in a standard CoA-Request message that contains the following VSA:

```
Cisco:Avpair="subscriber:command=bounce-host-port"
```

Because this command is session-oriented, it must be accompanied by one or more of the session identification attributes. If the session cannot be located, the switch returns a CoA-NAK message with the “Session Context Not Found” error-code attribute. If the session is located, the switch disables the hosting port for a period of 10 seconds, re-enables it (port-bounce), and returns a CoA-ACK.

If the switch fails before returning a CoA-ACK to the client, the process is repeated on the new active switch when the request is re-sent from the client. If the switch fails after returning a CoA-ACK message to the client but before the operation has completed, the operation is re-started on the new active switch.

#### Related Topics

[Session Identification](#), on page 1790

## Stacking Guidelines for Session Termination

No special handling is required for CoA Disconnect-Request messages in a switch stack.

### Stacking Guidelines for CoA-Request Bounce-Port

Because the **bounce-port** command is targeted at a session, not a port, if the session is not found, the command cannot be executed.

When the Auth Manager command handler on the stack master receives a valid **bounce-port** command, it checkpoints the following information before returning a CoA-ACK message:

- the need for a port-bounce
- the port-id (found in the local session context)

The switch initiates a port-bounce (disables the port for 10 seconds, then re-enables it).

If the port-bounce is successful, the signal that triggered the port-bounce is removed from the standby stack master.

If the stack master fails before the port-bounce completes, a port-bounce is initiated after stack master change-over based on the original command (which is subsequently removed).

If the stack master fails before sending a CoA-ACK message, the new stack master treats the re-sent command as a new command.

### Stacking Guidelines for CoA-Request Disable-Port

Because the **disable-port** command is targeted at a session, not a port, if the session is not found, the command cannot be executed.

When the Auth Manager command handler on the stack master receives a valid **disable-port** command, it verifies this information before returning a CoA-ACK message:

- the need for a port-disable
- the port-id (found in the local session context)

The switch attempts to disable the port.

If the port-disable operation is successful, the signal that triggered the port-disable is removed from the standby stack master.

If the stack master fails before the port-disable operation completes, the port is disabled after stack master change-over based on the original command (which is subsequently removed).

If the stack master fails before sending a CoA-ACK message, the new stack master treats the re-sent command as a new command.

## Default RADIUS Configuration

RADIUS and AAA are disabled by default.

To prevent a lapse in security, you cannot configure RADIUS through a network management application. When enabled, RADIUS can authenticate users accessing the switch through the CLI.

## RADIUS Server Host

Switch-to-RADIUS-server communication involves several components:

- Hostname or IP address
- Authentication destination port
- Accounting destination port



- Key string
- Timeout period
- Retransmission value

You identify RADIUS security servers by their hostname or IP address, hostname and specific UDP port numbers, or their IP address and specific UDP port numbers. The combination of the IP address and the UDP port number creates a unique identifier, allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. This unique identifier enables RADIUS requests to be sent to multiple UDP ports on a server at the same IP address.

If two different host entries on the same RADIUS server are configured for the same service—for example, accounting—the second host entry configured acts as a fail-over backup to the first one. Using this example, if the first host entry fails to provide accounting services, the %RADIUS-4-RADIUS\_DEAD message appears, and then the switch tries the second host entry configured on the same device for accounting services. (The RADIUS host entries are tried in the order that they are configured.)

A RADIUS server and the switch use a shared secret text string to encrypt passwords and exchange responses. To configure RADIUS to use the AAA security commands, you must specify the host running the RADIUS server daemon and a secret text (key) string that it shares with the switch.

The timeout, retransmission, and encryption key values can be configured globally for all RADIUS servers, on a per-server basis, or in some combination of global and per-server settings.

#### Related Topics

- [Identifying the RADIUS Server Host](#), on page 1808
- [Defining AAA Server Groups](#), on page 1813
- [Configuring Settings for All RADIUS Servers](#), on page 1817
- [Configuring RADIUS Login Authentication](#), on page 1811

## RADIUS Login Authentication

To configure AAA authentication, you define a named list of authentication methods and then apply that list to various ports. The method list defines the types of authentication to be performed and the sequence in which they are performed; it must be applied to a specific port before any of the defined authentication methods are performed. The only exception is the default method list. The default method list is automatically applied to all ports except those that have a named method list explicitly defined.

A method list describes the sequence and authentication methods to be queried to authenticate a user. You can designate one or more security protocols to be used for authentication, thus ensuring a backup system for authentication in case the initial method fails. The software uses the first method listed to authenticate users; if that method fails to respond, the software selects the next authentication method in the method list. This process continues until there is successful communication with a listed authentication method or until all defined methods are exhausted. If authentication fails at any point in this cycle—meaning that the security server or local username database responds by denying the user access—the authentication process stops, and no other authentication methods are attempted.

#### Related Topics

- [Configuring RADIUS Login Authentication](#), on page 1811

## AAA Server Groups

You can configure the switch to use AAA server groups to group existing server hosts for authentication. You select a subset of the configured server hosts and use them for a particular service. The server group is used with a global server-host list, which lists the IP addresses of the selected server hosts.

Server groups also can include multiple host entries for the same server if each entry has a unique identifier (the combination of the IP address and UDP port number), allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. This unique identifier enables RADIUS requests to be sent to different UDP ports on a server at the same IP address. If you configure two different host entries on the same RADIUS server for the same service, (for example, accounting), the second configured host entry acts as a fail-over backup to the first one. If the first host entry fails to provide accounting services, the network access server tries the second host entry configured on the same device for accounting services. (The RADIUS host entries are tried in the order in which they are configured.)

### Related Topics

[Defining AAA Server Groups](#), on page 1813

## AAA Authorization

AAA authorization limits the services available to a user. When AAA authorization is enabled, the switch uses information retrieved from the user's profile, which is in the local user database or on the security server, to configure the user's session. The user is granted access to a requested service only if the information in the user profile allows it.

### Related Topics

[Configuring RADIUS Authorization for User Privileged Access and Network Services](#), on page 1815

## RADIUS Accounting

The AAA accounting feature tracks the services that users are using and the amount of network resources that they are consuming. When you enable AAA accounting, the switch reports user activity to the RADIUS security server in the form of accounting records. Each accounting record contains accounting attribute-value (AV) pairs and is stored on the security server. You can then analyze the data for network management, client billing, or auditing.

### Related Topics

[Starting RADIUS Accounting](#), on page 1816

## Vendor-Specific RADIUS Attributes

The Internet Engineering Task Force (IETF) draft standard specifies a method for communicating vendor-specific information between the switch and the RADIUS server by using the vendor-specific attribute (attribute 26). Vendor-specific attributes (VSAs) allow vendors to support their own extended attributes not suitable for general use. The Cisco RADIUS implementation supports one vendor-specific option by using the format recommended in the specification. Cisco's vendor-ID is 9, and the supported option has vendor-type 1, which is named *cisco-avpair*. The value is a string with this format:

```
protocol : attribute sep value *
```

*Protocol* is a value of the Cisco protocol attribute for a particular type of authorization. *Attribute* and *value* are an appropriate attributevalue (AV) pair defined in the Cisco TACACS+ specification, and *sep* is = for mandatory attributes and is \* for optional attributes. The full set of features available for TACACS+ authorization can then be used for RADIUS.

For example, the following AV pair causes Cisco's "multiple named IP address pools" feature to be activated during IP authorization (during PPP's Internet Protocol Control Protocol (IPCP) address assignment):

```
cisco-avpair= "ip:addr-pool=first"
```

If you insert an "\*", the AV pair "ip:addr-pool=first" becomes optional. Note that any AV pair can be made optional:

```
cisco-avpair= "ip:addr-pool*first"
```

The following example shows how to cause a user logging in from a network access server to have immediate access to EXEC commands:

```
cisco-avpair= "shell:priv-lvl=15"
```

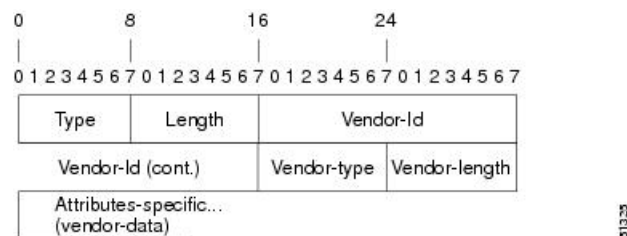
Other vendors have their own unique vendor-IDs, options, and associated VSAs. For more information about vendor-IDs and VSAs, see RFC 2138, "Remote Authentication Dial-In User Service (RADIUS)."

Attribute 26 contains the following three elements:

- Type
- Length
- String (also known as data)
  - Vendor-Id
  - Vendor-Type
  - Vendor-Length
  - Vendor-Data

The figure below shows the packet format for a VSA encapsulated "behind" attribute 26.

**Figure 109: VSA Encapsulated Behind Attribute 26**



**Note** It is up to the vendor to specify the format of their VSA. The Attribute-Specific field (also known as Vendor-Data) is dependent on the vendor's definition of that attribute.

The table below describes significant fields listed in the Vendor-Specific RADIUS IETF Attributes table (second table below), which lists supported vendor-specific RADIUS attributes (IETF attribute 26).

Table 134: Vendor-Specific Attributes Table Field Descriptions

Field	Description
Number	All attributes listed in the following table are extensions of IETF attribute 26.
Vendor-Specific Command Codes	A defined code used to identify a particular vendor. Code 9 defines Cisco VSAs, 311 defines Microsoft VSAs, and 529 defines Ascend VSAs.
Sub-Type Number	The attribute ID number. This number is much like the ID numbers of IETF attributes, except it is a “second layer” ID number encapsulated behind attribute 26.
Attribute	The ASCII string name of the attribute.
Description	Description of the attribute.

Table 135: Vendor-Specific RADIUS IETF Attributes

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
MS-CHAP Attributes				
26	311	1	MSCHAP-Response	Contains the response value provided by a PPP MS-CHAP user in response to the challenge. It is only used in Access-Request packets. This attribute is identical to the PPP CHAP Identifier. ( RFC 2548
26	311	11	MSCHAP-Challenge	Contains the challenge sent by a network access server to an MS-CHAP user. It can be used in both Access-Request and Access-Challenge packets. ( RFC 2548 )
VPDN Attributes				
26	9	1	l2tp-cm-local-window-size	Specifies the maximum receive window size for L2TP control messages. This value is advertised to the peer during tunnel establishment.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	l2tp-drop-out-of-order	Respects sequence numbers on data packets by dropping those that are received out of order. This does not ensure that sequence numbers will be sent on data packets, just how to handle them if they are received.
26	9	1	l2tp-hello-interval	Specifies the number of seconds for the hello keepalive interval. Hello packets are sent when no data has been sent on a tunnel for the number of seconds configured here.
26	9	1	l2tp-hidden-avp	When enabled, sensitive AVPs in L2TP control messages are scrambled or hidden.
26	9	1	l2tp-nosession-timeout	Specifies the number of seconds that a tunnel will stay active with no sessions before timing out and shutting down.
26	9	1	tunnel-tos-reflect	Copies the IP ToS field from the IP header of each payload packet to the IP header of the tunnel packet for packets entering the tunnel at the LNS.
26	9	1	l2tp-tunnel-authen	If this attribute is set, it performs L2TP tunnel authentication.
26	9	1	l2tp-tunnel-password	Shared secret used for L2TP tunnel authentication and AVP hiding.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	l2tp-udp-checksum	This is an authorization attribute and defines whether L2TP should perform UDP checksums for data packets. Valid values are “yes” and “no.” The default is no.
Store and Forward Fax Attributes				
26	9	3	Fax-Account-Id-Origin	Indicates the account ID origin as defined by system administrator for the <b>mmoip aaa receive-id</b> or the <b>mmoip aaa send-id</b> commands.
26	9	4	Fax-Msg-Id=	Indicates a unique fax message identification number assigned by Store and Forward Fax.
26	9	5	Fax-Pages	Indicates the number of pages transmitted or received during this fax session. This page count includes cover pages.
26	9	6	Fax-Coverpage-Flag	Indicates whether or not a cover page was generated by the off-ramp gateway for this fax session. True indicates that a cover page was generated; false means that a cover page was not generated.
26	9	7	Fax-Modem-Time	Indicates the amount of time in seconds the modem sent fax data (x) and the amount of time in seconds of the total fax session (y), which includes both fax-mail and PSTN time, in the form x/y. For example, 10/15 means that the transfer time took 10 seconds, and the total fax session took 15 seconds.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	8	Fax-Connect-Speed	Indicates the modem speed at which this fax-mail was initially transmitted or received. Possible values are 1200, 4800, 9600, and 14400.
26	9	9	Fax-Recipient-Count	Indicates the number of recipients for this fax transmission. Until e-mail servers support Session mode, the number should be 1.
26	9	10	Fax-Process-Abort-Flag	Indicates that the fax session was aborted or successful. True means that the session was aborted; false means that the session was successful.
26	9	11	Fax-Dsn-Address	Indicates the address to which DSNs will be sent.
26	9	12	Fax-Dsn-Flag	Indicates whether or not DSN has been enabled. True indicates that DSN has been enabled; false means that DSN has not been enabled.
26	9	13	Fax-Mdn-Address	Indicates the address to which MDNs will be sent.
26	9	14	Fax-Mdn-Flag	Indicates whether or not message delivery notification (MDN) has been enabled. True indicates that MDN had been enabled; false means that MDN had not been enabled.
26	9	15	Fax-Auth-Status	Indicates whether or not authentication for this fax session was successful. Possible values for this field are success, failed, bypassed, or unknown.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	16	Email-Server-Address	Indicates the IP address of the e-mail server handling the on-ramp fax-mail message.
26	9	17	Email-Server-Ack-Flag	Indicates that the on-ramp gateway has received a positive acknowledgment from the e-mail server accepting the fax-mail message.
26	9	18	Gateway-Id	Indicates the name of the gateway that processed the fax session. The name appears in the following format: hostname.domain-name.
26	9	19	Call-Type	Describes the type of fax activity: fax receive or fax send.
26	9	20	Port-Used	Indicates the slot/port number of the Cisco AS5300 used to either transmit or receive this fax-mail.
26	9	21	Abort-Cause	If the fax session aborts, indicates the system component that signaled the abort. Examples of system components that could trigger an abort are FAP (Fax Application Process), TIFF (the TIFF reader or the TIFF writer), fax-mail client, fax-mail server, ESMTTP client, or ESMTTP server.
H323 Attributes				
26	9	23	Remote-Gateway-ID (h323-remote-address)	Indicates the IP address of the remote gateway.
26	9	24	Connection-ID (h323-conf-id)	Identifies the conference ID.



Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	25	Setup-Time (h323-setup-time)	Indicates the setup time for this connection in Coordinated Universal Time (UTC) formerly known as Greenwich Mean Time (GMT) and Zulu time.
26	9	26	Call-Origin (h323-call-origin)	Indicates the origin of the call relative to the gateway. Possible values are originating and terminating (answer).
26	9	27	Call-Type (h323-call-type)	Indicates call leg type. Possible values are <b>telephony</b> and <b>VoIP</b> .
26	9	28	Connect-Time (h323-connect-time)	Indicates the connection time for this call leg in UTC.
26	9	29	Disconnect-Time (h323-disconnect-time)	Indicates the time this call leg was disconnected in UTC.
26	9	30	Disconnect-Cause (h323-disconnect-cause)	Specifies the reason a connection was taken offline per Q.931 specification.
26	9	31	Voice-Quality (h323-voice-quality)	Specifies the impairment factor (ICPIF) affecting voice quality for a call.
26	9	33	Gateway-ID (h323-gw-id)	Indicates the name of the underlying gateway.
Large Scale Dialout Attributes				
26	9	1	callback-dialstring	Defines a dialing string to be used for callback.
26	9	1	data-service	No description available.
26	9	1	dial-number	Defines the number to dial.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	force-56	Determines whether the network access server uses only the 56 K portion of a channel, even when all 64 K appear to be available.
26	9	1	map-class	Allows the user profile to reference information configured in a map class of the same name on the network access server that dials out.
26	9	1	send-auth	Defines the protocol to use (PAP or CHAP) for username-password authentication following CLID authentication.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	send-name	<p>PPP name authentication. To apply for PAP, do not configure the <b>ppp pap sent-name password</b> command on the interface. For PAP, “preauth:send-name” and “preauth:send-secret” will be used as the PAP username and PAP password for outbound authentication. For CHAP, “preauth:send-name” will be used not only for outbound authentication, but also for inbound authentication. For a CHAP inbound case, the NAS will use the name defined in “preauth:send-name” in the challenge packet to the caller box.</p> <p><b>Note</b> The send-name attribute has changed over time: Initially, it performed the functions now provided by both the send-name and remote-name attributes. Because the remote-name attribute has been added, the send-name attribute is restricted to its current behavior.</p>

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	send-secret	PPP password authentication. The vendor-specific attributes (VSAs) "preauth:send-name" and "preauth:send-secret" will be used as the PAP username and PAP password for outbound authentication. For a CHAP outbound case, both "preauth:send-name" and "preauth:send-secret" will be used in the response packet.
26	9	1	remote-name	Provides the name of the remote host for use in large-scale dial-out. Dialer checks that the large-scale dial-out remote name matches the authenticated name, to protect against accidental user RADIUS misconfiguration. (For example, dialing a valid phone number but connecting to the wrong device.)
Miscellaneous Attributes				

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	2	Cisco-NAS-Port	<p>Specifies additional vendor specific attribute (VSA) information for NAS-Port accounting. To specify additional NAS-Port information in the form an Attribute-Value Pair (AVPair) string, use the <b>radius-server vsa send</b> global configuration command.</p> <p><b>Note</b> This VSA is typically used in Accounting, but may also be used in Authentication (Access-Request) packets.</p>
26	9	1	min-links	Sets the minimum number of links for MLP.
26	9	1	proxyacl#<n>	Allows users to configure the downloadable user profiles (dynamic ACLs) by using the authentication proxy feature so that users can have the configured authorization to permit traffic going through the configured interfaces.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	spi	Carries the authentication information needed by the home agent to authenticate a mobile node during registration. The information is in the same syntax as the <b>ip mobile secure host &lt;addr&gt;</b> configuration command. Basically it contains the rest of the configuration command that follows that string, verbatim. It provides the Security Parameter Index (SPI), key, authentication algorithm, authentication mode, and replay protection timestamp range.

**Related Topics**

[Configuring the Device to Use Vendor-Specific RADIUS Attributes](#), on page 1819

## Vendor-Proprietary RADIUS Server Communication

Although an IETF draft standard for RADIUS specifies a method for communicating vendor-proprietary information between the switch and the RADIUS server, some vendors have extended the RADIUS attribute set in a unique way. Cisco IOS software supports a subset of vendor-proprietary RADIUS attributes.

As mentioned earlier, to configure RADIUS (whether vendor-proprietary or IETF draft-compliant), you must specify the host running the RADIUS server daemon and the secret text string it shares with the switch. You specify the RADIUS host and secret text string by using the **radius server** global configuration commands.

**Related Topics**

[Configuring the Device for Vendor-Proprietary RADIUS Server Communication](#)

## How to Configure RADIUS

### Identifying the RADIUS Server Host

To apply these settings globally to all RADIUS servers communicating with the Device, use the three unique global configuration commands: **radius-server timeout**, **radius-server retransmit**, and **key string**.

You can configure the Device to use AAA server groups to group existing server hosts for authentication. For more information, see Related Topics below.

You also need to configure some settings on the RADIUS server. These settings include the IP address of the Device and the key string to be shared by both the server and the Device. For more information, see the RADIUS server documentation.

Follow these steps to configure per-server RADIUS server communication.

### Before you begin

If you configure both global and per-server functions (timeout, retransmission, and key commands) on the device, the per-server timer, retransmission, and key value commands override global timer, retransmission, and key value commands. For information on configuring these settings on all RADIUS servers, see Related Topics below.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>radius server</b> <i>server name</i> <b>Example:</b> Device (config)# <b>radius server rsim</b>	
<b>Step 4</b>	<b>address</b> { <b>ipv4</b>   <b>ipv6</b> } <i>ip address</i> { <b>auth-port</b> <i>port number</i>   <b>acct-port</b> <i>port number</i> } <b>Example:</b> Device (config-radius-server)# <b>address ipv4 124.2.2.12 auth-port 1612</b>	(Optional) Specifies the RADIUS server parameters.  For <b>auth-port</b> <i>port-number</i> , specify the UDP destination port for authentication requests. The default is 1645. The range is 0 to 65536.  For <b>acct-port</b> <i>port-number</i> , specify the UDP destination port for authentication requests. The default is 1646.
<b>Step 5</b>	<b>key string</b> <b>Example:</b> Device (config-radius-server)# <b>key rad123</b>	(Optional) For <b>key string</b> , specify the authentication and encryption key used between the Device and the RADIUS daemon running on the RADIUS server.

	Command or Action	Purpose
		<p><b>Note</b> The key is a text string that must match the encryption key used on the RADIUS server. Always configure the key as the last item in the <b>radius server</b> command. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key.</p>
<b>Step 6</b>	<p><b>retransmit</b> <i>value</i></p> <p><b>Example:</b></p> <pre>Device(config-radius-server)# retransmit 10</pre>	(Optional) Specifies the number of times a RADIUS request is resent when the server is not responding or responding slowly. The range is 1 to 100. This setting overrides the <b>radius-server retransmit</b> global configuration command setting.
<b>Step 7</b>	<p><b>timeout</b> <i>seconds</i></p> <p><b>Example:</b></p> <pre>Device(config-radius-server)# timeout 60</pre>	(Optional) Specifies the time interval that the Device waits for the RADIUS server to reply before sending a request again. The range is 1 to 1000. This setting overrides the <b>radius-server timeout</b> global configuration command setting.
<b>Step 8</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-server-tacacs)# exit</pre>	Exits the RADIUS server mode and enters the global configuration mode.
<b>Step 9</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 10</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 11</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config</pre>	(Optional) Saves your entries in the configuration file.



	Command or Action	Purpose
	<code>startup-config</code>	

### Related Topics

[RADIUS Server Host](#), on page 1794

[Defining AAA Server Groups](#), on page 1813

[Configuring Settings for All RADIUS Servers](#), on page 1817

## Configuring RADIUS Login Authentication

Follow these steps to configure RADIUS login authentication:

### Before you begin

To secure the device for HTTP access by using AAA methods, you must configure the device with the **ip http authentication aaa** global configuration command. Configuring AAA authentication does not secure the device for HTTP access by using AAA methods.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>aaa new-model</b> <b>Example:</b> <pre>Device(config)# aaa new-model</pre>	Enables AAA.
<b>Step 4</b>	<b>aaa authentication login {default   list-name} method1 [method2...]</b> <b>Example:</b> <pre>Device(config)# aaa authentication login default local</pre>	Creates a login authentication method list. <ul style="list-style-type: none"> <li>• To create a default list that is used when a named list is <i>not</i> specified in the <b>login authentication</b> command, use the <b>default</b> keyword followed by the methods that are to be used in default situations. The default method list is automatically applied to all ports.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• For <i>list-name</i>, specify a character string to name the list you are creating.</li> <li>• For <i>methodl...</i>, specify the actual method the authentication algorithm tries. The additional methods of authentication are used only if the previous method returns an error, not if it fails.</li> </ul> <p>Select one of these methods:</p> <ul style="list-style-type: none"> <li>• <i>enable</i>—Use the enable password for authentication. Before you can use this authentication method, you must define an enable password by using the <b>enable password</b> global configuration command.</li> <li>• <i>group radius</i>—Use RADIUS authentication. Before you can use this authentication method, you must configure the RADIUS server.</li> <li>• <i>line</i>—Use the line password for authentication. Before you can use this authentication method, you must define a line password. Use the <b>password password</b> line configuration command.</li> <li>• <i>local</i>—Use the local username database for authentication. You must enter username information in the database. Use the <b>username name password</b> global configuration command.</li> <li>• <i>local-case</i>—Use a case-sensitive local username database for authentication. You must enter username information in the database by using the <b>username password</b> global configuration command.</li> <li>• <i>none</i>—Do not use any authentication for login.</li> </ul>
<b>Step 5</b>	<b>line</b> [ <b>console</b>   <b>tty</b>   <b>vty</b> ] <i>line-number</i> <i>[ending-line-number]</i> <b>Example:</b>	Enters line configuration mode, and configure the lines to which you want to apply the authentication list.

	Command or Action	Purpose
	Device(config)# <b>line 1 4</b>	
<b>Step 6</b>	<b>login authentication {default   list-name}</b> <b>Example:</b> Device(config)# <b>login authentication default</b>	Applies the authentication list to a line or set of lines. <ul style="list-style-type: none"> <li>• If you specify <b>default</b>, use the default list created with the <b>aaa authentication login</b> command.</li> <li>• For <i>list-name</i>, specify the list created with the <b>aaa authentication login</b> command.</li> </ul>
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[RADIUS Login Authentication](#), on page 1795

[RADIUS Server Host](#), on page 1794

## Defining AAA Server Groups

You use the **server** group server configuration command to associate a particular server with a defined group server. You can either identify the server by its IP address or identify multiple host instances or entries by using the optional **auth-port** and **acct-port** keywords.

Follow these steps to define AAA server groups:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>	Enables privileged EXEC mode.

	Command or Action	Purpose
	<b>Example:</b>  Device> <b>enable</b>	<ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>radius server name</b>  <b>Example:</b>  Device(config)# <b>radius server ISE</b>	Specifies the name of the RADIUS server configuration for Protected Access Credential (PAC) provisioning and enters RADIUS server configuration mode.  The device also supports RADIUS for IPv6.
<b>Step 4</b>	<b>address {ipv4   ipv6} {ip-address   hostname}</b> <b>auth-port port-number acct-port port-number</b>  <b>Example:</b>  Device(config-radius-server)# <b>address</b> <b>ipv4 10.1.1.1 auth-port 1645 acct-port</b> <b>1646</b>	Configures the IPv4 address for the RADIUS server accounting and authentication parameters.
<b>Step 5</b>	<b>key string</b>  <b>Example:</b>  Device(config-radius-server)# <b>key</b> <b>cisco123</b>	Specifies the authentication and encryption key for all RADIUS communications between the device and the RADIUS server.
<b>Step 6</b>	<b>end</b>  <b>Example:</b>  Device(config-radius-server)# <b>end</b>	Exits RADIUS server configuration mode and returns to privileged EXEC mode.
<b>Step 7</b>	<b>show running-config</b>  <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <b>copy running-config</b>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	<code>startup-config</code>	

#### Related Topics

[Identifying the RADIUS Server Host](#), on page 1808

[RADIUS Server Host](#), on page 1794

[AAA Server Groups](#), on page 1796

## Configuring RADIUS Authorization for User Privileged Access and Network Services



**Note** Authorization is bypassed for authenticated users who log in through the CLI even if authorization has been configured.

Follow these steps to configure RADIUS authorization for user privileged access and network services:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>aaa authorization network radius</b> <b>Example:</b> Device(config)# <code>aaa authorization network radius</code>	Configures the device for user RADIUS authorization for all network-related service requests.
<b>Step 4</b>	<b>aaa authorization exec radius</b> <b>Example:</b> Device(config)# <code>aaa authorization exec radius</code>	Configures the device for user RADIUS authorization if the user has privileged EXEC access.  The <code>exec</code> keyword might return user profile information (such as <b>autocommand</b> information).

	Command or Action	Purpose
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

### What to do next

You can use the **aaa authorization** global configuration command with the **radius** keyword to set parameters that restrict a user's network access to privileged EXEC mode.

The **aaa authorization exec radius local** command sets these authorization parameters:

- Use RADIUS for privileged EXEC access authorization if authentication was performed by using RADIUS.
- Use the local database if authentication was not performed by using RADIUS.

### Related Topics

[AAA Authorization](#), on page 1796

## Starting RADIUS Accounting

Follow these steps to start RADIUS accounting:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>aaa accounting network start-stop radius</b> <b>Example:</b> Device(config)# <code>aaa accounting network start-stop radius</code>	Enables RADIUS accounting for all network-related service requests.
<b>Step 4</b>	<b>aaa accounting exec start-stop radius</b> <b>Example:</b> Device(config)# <code>aaa accounting exec start-stop radius</code>	Enables RADIUS accounting to send a start-record accounting notice at the beginning of a privileged EXEC process and a stop-record at the end.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> Device# <code>show running-config</code>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[RADIUS Accounting](#), on page 1796

## Configuring Settings for All RADIUS Servers

Beginning in privileged EXEC mode, follow these steps to configure settings for all RADIUS servers:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>radius-server key <i>string</i></b> <b>Example:</b> Device(config)# <b>radius-server key your_server_key</b> Device(config)# <b>key your_server_key</b>	Specifies the shared secret text string used between the switch and all RADIUS servers. <b>Note</b> The key is a text string that must match the encryption key used on the RADIUS server. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key.
<b>Step 3</b>	<b>radius-server retransmit <i>retries</i></b> <b>Example:</b> Device(config)# <b>radius-server retransmit 5</b>	Specifies the number of times the switch sends each RADIUS request to the server before giving up. The default is 3; the range 1 to 1000.
<b>Step 4</b>	<b>radius-server timeout <i>seconds</i></b> <b>Example:</b> Device(config)# <b>radius-server timeout 3</b>	Specifies the number of seconds a switch waits for a reply to a RADIUS request before resending the request. The default is 5 seconds; the range is 1 to 1000.
<b>Step 5</b>	<b>radius-server deadtime <i>minutes</i></b> <b>Example:</b> Device(config)# <b>radius-server deadtime 0</b>	When a RADIUS server is not responding to authentication requests, this command specifies a time to stop the request on that server. This avoids the wait for the request to timeout before trying the next configured server. The default is 0; the range is 1 to 1440 minutes.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show running-config</b> <b>Example:</b>	Verifies your entries.



	Command or Action	Purpose
	Device# <code>show running-config</code>	
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Identifying the RADIUS Server Host](#), on page 1808

[RADIUS Server Host](#), on page 1794

## Configuring the Device to Use Vendor-Specific RADIUS Attributes

Follow these steps to configure the device to use vendor-specific RADIUS attributes:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>radius-server vsa send [accounting   authentication]</b> <b>Example:</b> Device(config)# <code>radius-server vsa send accounting</code>	Enables the device to recognize and use VSAs as defined by RADIUS IETF attribute 26. <ul style="list-style-type: none"> <li>• (Optional) Use the <b>accounting</b> keyword to limit the set of recognized vendor-specific attributes to only accounting attributes.</li> <li>• (Optional) Use the <b>authentication</b> keyword to limit the set of recognized vendor-specific attributes to only authentication attributes.</li> </ul>

	Command or Action	Purpose
		If you enter this command without keywords, both accounting and authentication vendor-specific attributes are used.
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Vendor-Specific RADIUS Attributes](#), on page 1796

## Configuring the Device for Vendor-Proprietary RADIUS Server Communication

Follow these steps to configure the device to use vendor-proprietary RADIUS server communication:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>radius server</b> <i>server name</i> <b>Example:</b>	Specifies the RADIUS server.

	Command or Action	Purpose
	Device (config) # <b>radius server rsim</b>	
<b>Step 4</b>	<b>address { ipv4   ipv6 } ip address</b> <b>Example:</b> Device (config-radius-server) # <b>address ipv4 172.24.25.10</b>	(Optional) Specifies the IP address of the RADIUS server.
<b>Step 5</b>	<b>non-standard</b> <b>Example:</b> Device (config-radius-server) # <b>non-standard</b>	Identifies that the RADIUS server using a vendor-proprietary implementation of RADIUS.
<b>Step 6</b>	<b>key string</b> <b>Example:</b> Device (config-radius-server) # <b>key rad123</b>	Specifies the shared secret text string used between the device and the vendor-proprietary RADIUS server. The device and the RADIUS server use this text string to encrypt passwords and exchange responses.
<b>Step 7</b>	<b>exit</b> <b>Example:</b> Device (config-radius-server) # <b>exit</b>	Exits the RADIUS server mode and enters the global configuration mode.
<b>Step 8</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 9</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 10</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring CoA on the Device

Follow these steps to configure CoA on a device. This procedure is required.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>aaa new-model</b> <b>Example:</b> Device (config)# <b>aaa new-model</b>	Enables AAA.
<b>Step 4</b>	<b>aaa server radius dynamic-author</b> <b>Example:</b> Device (config)# <b>aaa server radius dynamic-author</b>	Configures the device as an authentication, authorization, and accounting (AAA) server to facilitate interaction with an external policy server.
<b>Step 5</b>	<b>client</b> <i>{ip-address   name}</i> [ <b>vrf</b> <i>vrfname</i> ] <b>[server-key string]</b>	Enters dynamic authorization local server configuration mode and specifies a RADIUS client from which a device will accept CoA and disconnect requests.
<b>Step 6</b>	<b>server-key</b> [0   7] <i>string</i> <b>Example:</b> Device (config-sg-radius)# <b>server-key your_server_key</b>	Configures the RADIUS key to be shared between a device and RADIUS clients.
<b>Step 7</b>	<b>port</b> <i>port-number</i> <b>Example:</b> Device (config-sg-radius)# <b>port 25</b>	Specifies the port on which a device listens for RADIUS requests from configured RADIUS clients.

	Command or Action	Purpose
<b>Step 8</b>	<b>auth-type</b> {any   all   session-key} <b>Example:</b> Device(config-sg-radius)# <b>auth-type any</b>	Specifies the type of authorization the device uses for RADIUS clients.  The client must match all the configured attributes for authorization.
<b>Step 9</b>	<b>ignore session-key</b>	(Optional) Configures the device to ignore the session-key.  For more information about the <b>ignore</b> command, see the <i>Cisco IOS Intelligent Services Gateway Command Reference</i> on Cisco.com.
<b>Step 10</b>	<b>ignore server-key</b> <b>Example:</b> Device(config-sg-radius)# <b>ignore server-key</b>	(Optional) Configures the device to ignore the server-key.  For more information about the <b>ignore</b> command, see the <i>Cisco IOS Intelligent Services Gateway Command Reference</i> on Cisco.com.
<b>Step 11</b>	<b>authentication command bounce-port ignore</b> <b>Example:</b> Device(config-sg-radius)# <b>authentication command bounce-port ignore</b>	(Optional) Configures the device to ignore a CoA request to temporarily disable the port hosting a session. The purpose of temporarily disabling the port is to trigger a DHCP renegotiation from the host when a VLAN change occurs and there is no supplicant on the endpoint to detect the change.
<b>Step 12</b>	<b>authentication command disable-port ignore</b> <b>Example:</b> Device(config-sg-radius)# <b>authentication command disable-port ignore</b>	(Optional) Configures the device to ignore a nonstandard command requesting that the port hosting a session be administratively shut down. Shutting down the port results in termination of the session.  Use standard CLI or SNMP commands to re-enable the port.
<b>Step 13</b>	<b>end</b> <b>Example:</b> Device(config-sg-radius)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 14</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.

	Command or Action	Purpose
<b>Step 15</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Monitoring CoA Functionality

*Table 136: Privileged EXEC show Commands*

Command	Purpose
<b>show aaa attributes protocol radius</b>	Displays AAA attributes of RADIUS commands.

*Table 137: Global Troubleshooting Commands*

Command	Purpose
<b>debug radius</b>	Displays information for troubleshooting RADIUS.
<b>debug aaa coa</b>	Displays information for troubleshooting CoA processing.
<b>debug aaa pod</b>	Displays information for troubleshooting POD packets.
<b>debug aaa subsys</b>	Displays information for troubleshooting POD packets.
<b>debug cmdhd [detail   error   events]</b>	Displays information for troubleshooting command headers.

For detailed information about the fields in these displays, see the command reference for this release.

## Additional References for Configuring Secure Shell

### Related Documents

Related Topic	Document Title
Configuring Identity Control policies and Identity Service templates for Session Aware networking.	<a href="#">Session Aware Networking Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</a>
Configuring RADIUS, TACACS+, Secure Shell, 802.1X and AAA.	<a href="#">Securing User Services Configuration Guide Library, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</a>

**Error Message Decoder**

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**Standards and RFCs**

Standard/RFC	Title
None	

**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>







## CHAPTER 99

# Configuring RADIUS over DTLS

- [Finding Feature Information, on page 1827](#)
- [Prerequisites for RADIUS over DTLS, on page 1827](#)
- [Information about RADIUS over DTLS, on page 1827](#)
- [How to Configure RADIUS over DTLS, on page 1828](#)
- [Monitoring RADIUS over DTLS, on page 1830](#)
- [Examples of RADIUS over DTLS, on page 1831](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for RADIUS over DTLS

Following are the prerequisites for RADIUS over DTLS:

- Ensure that the device is running Cisco IOS crypto K9 image.
- Ensure that crypto PKI is configured on the device.
- Support for RADIUS over DTLS is available on Cisco ISE 2.2 and above.

## Information about RADIUS over DTLS

DTLS provides encryption services over RADIUS, which is transported over a secure tunnel. RADIUS over DTLS is implemented in both client and server. Client side controls radius Authentication, Authorization, and Accounting (AAA) and server side controls Change of Authorization (CoA).

You can configure the following parameters:

- Per client specific `idle_timeout`, client trustpoint and server trustpoint.
- Global CoA specific DTLS listening port and list of source interfaces.

You can disable DTLS for a specific server by using the command `no dtls` in the radius server configuration mode.

## How to Configure RADIUS over DTLS

### How to Configure DTLS Server

Although there is no configuration restriction, it is recommended to use the same type, either only DTLS or only non-DTLS, for server under a AAA server group.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>radius server</b> <i>radius-server-name</i> <b>Example:</b> Device(config)# <b>radius server R1</b>	Enters radius server configuration mode.
<b>Step 4</b>	<b>dtls</b> [ <b>connectiontimeout</b> <i>connection-timeout-value</i> ] [ <b>idletimeout</b> <i>idle-timeout-value</i> ] [ <b>ip</b> { <b>radius source-interface</b> <i>interface-name</i>   <b>vrf forwarding</b> <i>forwarding-table-name</i> } ] [ <b>port</b> <i>port-number</i> ] [ <b>retries</b> <i>number-of-connection-retries</i> ] [ <b>trustpoint</b> { <b>client</b> <i>trustpoint name</i>   <b>server</b> <i>trustpoint name</i> }] <b>Example:</b> Device(config-radius-server)# <b>dtls connectiontimeout 10</b> Device(config-radius-server)# <b>dtls idletimeout 5</b>	Configures DTLS parameters. You can configure the following parameters: <ul style="list-style-type: none"> <li>• <b>connectiontimeout</b> — Configures DTLS connection timeout value.</li> <li>• <b>idletimeout</b> — Configures DTLS idle timeout value.</li> <li>• <b>ip</b> — Configures IP source parameters.</li> <li>• <b>port</b> — Configures DTLS port number.</li> </ul>

	Command or Action	Purpose
	<pre>Device(config-radius-server)# dtls retries 15 Device(config-radius-server)# dtls ip radius source-interface Ethernet 0/0 Device(config-radius-server)# dtls ip vrf forwarding table-1 Device(config-radius-server)# dtls port 10 Device(config-radius-server)# dtls trustpoint Device(config-radius-server)# dtls trustpoint client TP-self-signed-721943660 Device(config-radius-server)# dtls trustpoint server isetp</pre>	<ul style="list-style-type: none"> <li>• <b>retries</b> — Configures number of DTLS connection retries.</li> <li>• <b>trustpoint</b> — Configures DTLS trustpoint for client and server.</li> </ul>
<b>Step 5</b>	<pre>end Example: Device(config-radius-server)# end</pre>	Returns to privileged EXEC mode.

## How to Configure Dynamic Authorization for DTLS CoA

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<pre>enable Example: Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<pre>configure terminal Example: Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<pre>aaa server radius dynamic-author Example: Device(config)# aaa server radius dynamic-author</pre>	<p>Enters dynamic authorization local server configuration mode and specifies a RADIUS client from which a device accepts Change of Authorization (CoA) and disconnect requests. Configures the device as a AAA server to facilitate interaction with an external policy server.</p>

	Command or Action	Purpose
Step 4	<p><b>client</b> {ip-addr   hostname} [dtls [client-tp client-tp-name] [idletimeout idletimeout-interval] [server-tp server-tp-name]]   vrf vrf-id ]</p> <p><b>Example:</b></p> <pre>Device(config-locsvr-da-radius)# client 10.104.49.14 dtls idletimeout 100 client-tp dtls_ise server-tp dtls_client</pre>	<p>Configures the IP address or hostname of the AAA server client. You can configure the following optional parameters:</p> <ul style="list-style-type: none"> <li>• <b>dtls</b> — Enables DTLS for the client.</li> <li>• <b>client-tp</b> — Configures client trustpoint.</li> <li>• <b>idletimeout</b> — Configures DTLS idle timeout value.</li> <li>• <b>server-tp</b> — Configures server trustpoint.</li> <li>• <b>vrf</b> — Virtual routing and forwarding (VRF) ID of the client.</li> </ul>
Step 5	<p><b>dtls</b> {ip radius source-interface interface-name   port radius-dtls-server-port-number}</p> <p><b>Example:</b></p> <pre>Device(config-locsvr-da-radius)# dtls ip radius source-interface GigabitEthernet 1/0/24  Device(config-locsvr-da-radius)# dtls port 100</pre>	<p>Configures RADIUS CoA server. You can configure the following parameters:</p> <ul style="list-style-type: none"> <li>• <b>ip radius source-interface</b> interface-name — Specifies the interface for source address in RADIUS CoA Server.</li> <li>• <b>port</b> radius-dtls-server-port-number — Specifies port on which local DTLS RADIUS server listens.</li> </ul>
Step 6	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-radius-server)# end</pre>	<p>Returns to privileged EXEC mode.</p>

## Monitoring RADIUS over DTLS

The following commands can be used to monitor DTLS server statistics:

Table 138: Monitoring DTLS Server Statistics Command

Command	Purpose
<b>show aaa servers</b>	Displays information related to DTLS server. Following statistics information is displayed using <b>show aaa servers</b> command: <ul style="list-style-type: none"> <li>• pkt_cnt_since_idle_tiemout</li> <li>• send_hs_start_cnt</li> <li>• hs_success_cnt</li> <li>• total_tx_pkt_cnt</li> <li>• total_rx_pkt_cnt</li> <li>• total_conn_reset_cnt</li> <li>• conn_reset_cnt_idle_timeout</li> <li>• conn_reset_cnt_no_resp</li> <li>• conn_reset_cnt_malformed_pkt</li> <li>• conn_reset_cnt_error_case</li> </ul>
<b>clear aaa counters servers radius</b> { <i>server id</i>   <b>all</b> }	Clears the RADIUS DTLS specific statistics.
<b>debug radius dtls</b>	Enables RADIUS DTLS specific debugs.

## Examples of RADIUS over DTLS

The following is a sample output for the statistics per DTLS connection:

```
Device# show aaa servers
RADIUS: id 53, priority 1, host 11.22.45.45, DTLS port 2083
State: current UP, duration 1596921s, previous duration 0s
Dead: total time 0s, count 0
Platform State from SMD: current DEAD, duration 53s, previous duration
0s
SMD Platform Dead: total time 1197328s, count 19957
Platform State from WNCN: current UP, duration 0s, previous duration 0s
Platform Dead: total time 0s, count 0
Quarantined: No
Authen: request 0, timeouts 0, failover 0, retransmission 0
Response: accept 0, reject 0, challenge 0
Response: unexpected 0, server error 0, incorrect 0, time 0ms
Transaction: success 0, failure 0
Throttled: transaction 0, timeout 0, failure 0
Author: request 0, timeouts 0, failover 0, retransmission 0
Response: accept 0, reject 0, challenge 0
Response: unexpected 0, server error 0, incorrect 0, time 0ms
Transaction: success 0, failure 0
Throttled: transaction 0, timeout 0, failure 0
Account: request 0, timeouts 0, failover 0, retransmission 0
Request: start 0, interim 0, stop 0
Response: start 0, interim 0, stop 0
```

```
Response: unexpected 0, server error 0, incorrect 0, time 0ms
Transaction: success 0, failure 0
Throttled: transaction 0, timeout 0, failure 0
DTLS: Packet count since last idletimeout 0,
Send handshake count 0,
Handshake Success 0,
Total Packets Transmitted 0,
Total Packets Received 0,
Total Connection Resets 0,
Connection Reset due to idle timeout 0,
Connection Reset due to No Response 0,
Connection Reset due to Malformed packet 0,
Connection Reset by Peer 0,
Connection Reset due to other Errors 0,
Elapsed time since counters last cleared: 0m
Estimated Outstanding Access Transactions: 0
Estimated Outstanding Accounting Transactions: 468
Estimated Throttled Access Transactions: 0
Estimated Throttled Accounting Transactions: 0
Maximum Throttled Transactions: access 0, accounting 0
```



## CHAPTER 100

# Configuring Kerberos

- [Finding Feature Information, on page 1833](#)
- [Prerequisites for Controlling Switch Access with Kerberos, on page 1833](#)
- [Information about Kerberos, on page 1834](#)
- [How to Configure Kerberos, on page 1837](#)
- [Monitoring the Kerberos Configuration, on page 1837](#)
- [Additional References, on page 1837](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Controlling Switch Access with Kerberos

The following are the prerequisites for controlling switch access with Kerberos.

- So that remote users can authenticate to network services, you must configure the hosts and the KDC in the Kerberos realm to communicate and mutually authenticate users and network services. To do this, you must identify them to each other. You add entries for the hosts to the Kerberos database on the KDC and add KEYTAB files generated by the KDC to all hosts in the Kerberos realm. You also create entries for the users in the KDC database.
- A Kerberos server can be a switch that is configured as a network security server and that can authenticate users by using the Kerberos protocol.

When you add or create entries for the hosts and users, follow these guidelines:

- The Kerberos principal name *must* be in all lowercase characters.
- The Kerberos instance name *must* be in all lowercase characters.

- The Kerberos realm name *must* be in all uppercase characters.

## Information about Kerberos

This section provides Kerberos information.

### Kerberos and Switch Access

This section describes how to enable and configure the Kerberos security system, which authenticates requests for network resources by using a trusted third party.



---

**Note** In the Kerberos configuration examples, the trusted third party can be any switch that supports Kerberos, that is configured as a network security server, and that can authenticate users by using the Kerberos protocol.

---

### Kerberos Overview

Kerberos is a secret-key network authentication protocol, which was developed at the Massachusetts Institute of Technology (MIT). It uses the Data Encryption Standard (DES) cryptographic algorithm for encryption and authentication and authenticates requests for network resources. Kerberos uses the concept of a trusted third party to perform secure verification of users and services. This trusted third party is called the *key distribution center* (KDC).

Kerberos verifies that users are who they claim to be and the network services that they use are what the services claim to be. To do this, a KDC or trusted Kerberos server issues tickets to users. These tickets, which have a limited life span, are stored in user credential caches. The Kerberos server uses the tickets instead of user names and passwords to authenticate users and network services.



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**Note** A Kerberos server can be any switch that is configured as a network security server and that can authenticate users by using the Kerberos protocol.

---

The Kerberos credential scheme uses a process called *single logon*. This process authenticates a user once and then allows secure authentication (without encrypting another password) wherever that user credential is accepted.

This software release supports Kerberos 5, which allows organizations that are already using Kerberos 5 to use the same Kerberos authentication database on the KDC that they are already using on their other network hosts (such as UNIX servers and PCs).

Kerberos supports these network services:

- Telnet
- rlogin
- rsh



This table lists the common Kerberos-related terms and definitions.

**Table 139: Kerberos Terms**

Term	Definition
Authentication	A process by which a user or service identifies itself to another service. For example, a client can authenticate to a switch or a switch can authenticate to another switch.
Authorization	A means by which the switch identifies what privileges the user has in a network or on the switch and what actions the user can perform.
Credential	A general term that refers to authentication tickets, such as TGTs <sup>9</sup> and service credentials. Kerberos credentials verify the identity of a user or service. If a network service decides to trust the Kerberos server that issued a ticket, it can be used in place of re-entering a username and password. Credentials have a default life span of eight hours.
Instance	An authorization level label for Kerberos principals. Most Kerberos principals are of the form <i>user@REALM</i> (for example, smith@EXAMPLE.COM). A Kerberos principal with a Kerberos instance has the form <i>user/instance@REALM</i> (for example, smith/admin@EXAMPLE.COM). The Kerberos instance can be used to specify the authorization level for the user if authentication is successful. The server of each network service might implement and enforce the authorization mappings of Kerberos instances but is not required to do so.  <b>Note</b> The Kerberos principal and instance names <i>must</i> be in all lowercase characters.  <b>Note</b> The Kerberos realm name <i>must</i> be in all uppercase characters.
KDC <sup>10</sup>	Key distribution center that consists of a Kerberos server and database program that is running on a network host.
Kerberized	A term that describes applications and services that have been modified to support the Kerberos credential infrastructure.
Kerberos realm	A domain consisting of users, hosts, and network services that are registered to a Kerberos server. The Kerberos server is trusted to verify the identity of a user or network service to another user or network service.  <b>Note</b> The Kerberos realm name <i>must</i> be in all uppercase characters.
Kerberos server	A daemon that is running on a network host. Users and network services register their identity with the Kerberos server. Network services query the Kerberos server to authenticate to other network services.
KEYTAB <sup>11</sup>	A password that a network service shares with the KDC. In Kerberos 5 and later Kerberos versions, the network service authenticates an encrypted service credential by using the KEYTAB to decrypt it. In Kerberos versions earlier than Kerberos 5, KEYTAB is referred to as SRVTAB <sup>12</sup> .
Principal	Also known as a Kerberos identity, this is who you are or what a service is according to the Kerberos server.  <b>Note</b> The Kerberos principal name <i>must</i> be in all lowercase characters.

Term	Definition
Service credential	A credential for a network service. When issued from the KDC, this credential is encrypted with the password shared by the network service and the KDC. The password is also shared with the user TGT.
SRVTAB	A password that a network service shares with the KDC. In Kerberos 5 or later Kerberos versions, SRVTAB is referred to as KEYTAB.
TGT	Ticket granting ticket that is a credential that the KDC issues to authenticated users. When users receive a TGT, they can authenticate to network services within the Kerberos realm represented by the KDC.

<sup>9</sup> ticket granting ticket

<sup>10</sup> key distribution center

<sup>11</sup> key table

<sup>12</sup> server table

## Kerberos Operation

A Kerberos server can be a device that is configured as a network security server and that can authenticate remote users by using the Kerberos protocol. Although you can customize Kerberos in a number of ways, remote users attempting to access network services must pass through three layers of security before they can access network services.

To authenticate to network services by using a device as a Kerberos server, remote users must follow these steps:

### Authenticating to a Boundary Switch

This section describes the first layer of security through which a remote user must pass. The user must first authenticate to the boundary switch. This process then occurs:

1. The user opens an un-Kerberized Telnet connection to the boundary switch.
2. The switch prompts the user for a username and password.
3. The switch requests a TGT from the KDC for this user.
4. The KDC sends an encrypted TGT that includes the user identity to the switch.
5. The switch attempts to decrypt the TGT by using the password that the user entered.
  - If the decryption is successful, the user is authenticated to the switch.
  - If the decryption is not successful, the user repeats Step 2 either by re-entering the username and password (noting if Caps Lock or Num Lock is on or off) or by entering a different username and password.

A remote user who initiates a un-Kerberized Telnet session and authenticates to a boundary switch is inside the firewall, but the user must still authenticate directly to the KDC before getting access to the network services. The user must authenticate to the KDC because the TGT that the KDC issues is stored on the switch and cannot be used for additional authentication until the user logs on to the switch.

## Obtaining a TGT from a KDC

This section describes the second layer of security through which a remote user must pass. The user must now authenticate to a KDC and obtain a TGT from the KDC to access network services.

For instructions about how to authenticate to a KDC, see the “Obtaining a TGT from a KDC” section in the “Security Server Protocols” chapter of the *Cisco IOS Security Configuration Guide, Release 12.4*.

## Authenticating to Network Services

This section describes the third layer of security through which a remote user must pass. The user with a TGT must now authenticate to the network services in a Kerberos realm.

For instructions about how to authenticate to a network service, see the “Authenticating to Network Services” section in the “Security Server Protocols” chapter of the *Cisco IOS Security Configuration Guide, Release 12.4*.

## How to Configure Kerberos

To set up a Kerberos-authenticated server-client system, follow these steps:

- Configure the KDC by using Kerberos commands.
- Configure the switch to use the Kerberos protocol.

## Monitoring the Kerberos Configuration

To display the Kerberos configuration, use the following commands:

- **show running-config**
- **show kerberos creds**: Lists the credentials in a current user’s credentials cache.
- **clear kerberos creds**: Destroys all credentials in a current user’s credentials cache, including those forwarded.

## Additional References

### Related Documents

Related Topic	Document Title
Kerberos Commands	<i>Cisco IOS Security Command Reference</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>



## CHAPTER 101

# Configuring Local Authentication and Authorization

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- [Finding Feature Information, on page 1839](#)
- [How to Configure Local Authentication and Authorization, on page 1839](#)
- [Monitoring Local Authentication and Authorization, on page 1842](#)
- [Additional References, on page 1842](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

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## How to Configure Local Authentication and Authorization

### Configuring the Switch for Local Authentication and Authorization

You can configure AAA to operate without a server by setting the switch to implement AAA in local mode. The switch then handles authentication and authorization. No accounting is available in this configuration.



---

**Note** To secure the switch for HTTP access by using AAA methods, you must configure the switch with the **ip http authentication aaa** global configuration command. Configuring AAA authentication does not secure the switch for HTTP access by using AAA methods.

---

Follow these steps to configure AAA to operate without a server by setting the switch to implement AAA in local mode:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>aaa new-model</b> <b>Example:</b> Device (config) # <b>aaa new-model</b>	Enables AAA.
<b>Step 4</b>	<b>aaa authentication login default local</b> <b>Example:</b> Device (config) # <b>aaa authentication login default local</b>	Sets the login authentication to use the local username database. The <b>default</b> keyword applies the local user database authentication to all ports.
<b>Step 5</b>	<b>aaa authorization exec default local</b> <b>Example:</b> Device (config) # <b>aaa authorization exec default local</b>	Configures user AAA authorization, check the local database, and allow the user to run an EXEC shell.
<b>Step 6</b>	<b>aaa authorization network default local</b> <b>Example:</b> Device (config) # <b>aaa authorization network default local</b>	Configures user AAA authorization for all network-related service requests.
<b>Step 7</b>	<b>username name [privilege level] {password encryption-type password}</b> <b>Example:</b> Device (config) # <b>username your_user_name privilege 1 password 7 secret567</b>	Enters the local database, and establishes a username-based authentication system. <p>Repeat this command for each user.</p> <ul style="list-style-type: none"> <li>• For <i>name</i>, specify the user ID as one word. Spaces and quotation marks are not allowed.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• (Optional) For <i>level</i>, specify the privilege level the user has after gaining access. The range is 0 to 15. Level 15 gives privileged EXEC mode access. Level 0 gives user EXEC mode access.</li> <li>• For <i>encryption-type</i>, enter 0 to specify that an unencrypted password follows. Enter 7 to specify that a hidden password follows.</li> <li>• For <i>password</i>, specify the password the user must enter to gain access to the switch. The password must be from 1 to 25 characters, can contain embedded spaces, and must be the last option specified in the <b>username</b> command.</li> </ul>
<b>Step 8</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 9</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 10</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[SSH Servers, Integrated Clients, and Supported Versions](#), on page 1845

[TACACS+ and Switch Access](#), on page 1731

[RADIUS and Switch Access](#), on page 1785

[Setting Up the Device to Run SSH](#), on page 1847

[SSH Configuration Guidelines](#), on page 1846

# Monitoring Local Authentication and Authorization

To display Local Authentication and Authorization configuration, use the **show running-config** privileged EXEC command.

## Additional References

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>





## CHAPTER 102

# Configuring Secure Shell



**Note** Starting with Cisco IOS XE Denali 16.3.1, Secure Shell Version 1 (SSHv1) is deprecated.

- [Finding Feature Information, on page 1843](#)
- [Prerequisites for Configuring Secure Shell, on page 1843](#)
- [Restrictions for Configuring Secure Shell, on page 1844](#)
- [Information About Configuring Secure Shell , on page 1845](#)
- [How to Configure SSH, on page 1847](#)
- [Monitoring the SSH Configuration and Status, on page 1850](#)
- [Additional References for Configuring Secure Shell, on page 1851](#)
- [Feature Information for Configuring Secure Shell, on page 1852](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Configuring Secure Shell

The following are the prerequisites for configuring the switch for secure shell (SSH):

- For SSH to work, the switch needs an Rivest, Shamir, and Adleman (RSA) public/private key pair. This is the same with Secure Copy Protocol (SCP), which relies on SSH for its secure transport.
- Before enabling SCP, you must correctly configure SSH, authentication, and authorization on the switch.
- Because SCP relies on SSH for its secure transport, the router must have an Rivest, Shamir, and Adelman (RSA) key pair.

- SCP relies on SSH for security.
- SCP requires that authentication, authorization, and accounting (AAA) authorization be configured so the router can determine whether the user has the correct privilege level.
- A user must have appropriate authorization to use SCP.
- A user who has appropriate authorization can use SCP to copy any file in the Cisco IOS File System (IFS) to and from a switch by using the **copy** command. An authorized administrator can also do this from a workstation.
- The Secure Shell (SSH) server requires an IPsec (Data Encryption Standard [DES] or 3DES) encryption software image; the SSH client requires an IPsec (DES or 3DES) encryption software image.)
- Configure a hostname and host domain for your device by using the **hostname** and **ip domain-name** commands in global configuration mode.

#### Related Topics

[Secure Copy Protocol](#), on page 1846

## Restrictions for Configuring Secure Shell

The following are restrictions for configuring the device for secure shell.

- The switch supports Rivest, Shamir, and Adelman (RSA) authentication.
- SSH supports only the execution-shell application.
- The SSH server and the SSH client are supported only on Data Encryption Standard (DES) (56-bit) and 3DES (168-bit) data encryption software. In DES software images, DES is the only encryption algorithm available. In 3DES software images, both DES and 3DES encryption algorithms are available.
- The device supports the Advanced Encryption Standard (AES) encryption algorithm with a 128-bit key, 192-bit key, or 256-bit key. However, symmetric cipher AES to encrypt the keys is not supported.
- When using SCP, you cannot enter the password into the **copy** command. You must enter the password when prompted.
- The login banner is not supported in Secure Shell Version 1. It is supported in Secure Shell Version 2.
- The **-l** keyword and **userid** : {number} {ip-address} delimiter and arguments are mandatory when configuring the alternative method of Reverse SSH for console access.
- To authenticate clients with freeradius over RADSEC, you should generate an RSA key longer than 1024 bit. Use the **crypto key generate rsa general-keys exportable label label-name** command to achieve this.

#### Related Topics

[Secure Copy Protocol](#), on page 1846

# Information About Configuring Secure Shell

Secure Shell (SSH) is a protocol that provides a secure, remote connection to a device. SSH provides more security for remote connections than Telnet does by providing strong encryption when a device is authenticated. This software release supports SSH Version 1 (SSHv1) and SSH Version 2 (SSHv2).

## SSH and Switch Access

Secure Shell (SSH) is a protocol that provides a secure, remote connection to a device. SSH provides more security for remote connections than Telnet does by providing strong encryption when a device is authenticated. This software release supports SSH Version 1 (SSHv1) and SSH Version 2 (SSHv2).

SSH functions the same in IPv6 as in IPv4. For IPv6, SSH supports IPv6 addresses and enables secure, encrypted connections with remote IPv6 nodes over an IPv6 transport.

## SSH Servers, Integrated Clients, and Supported Versions

The Secure Shell (SSH) Integrated Client feature is an application that runs over the SSH protocol to provide device authentication and encryption. The SSH client enables a Cisco device to make a secure, encrypted connection to another Cisco device or to any other device running the SSH server. This connection provides functionality similar to that of an outbound Telnet connection except that the connection is encrypted. With authentication and encryption, the SSH client allows for secure communication over an unsecured network.

The SSH server and SSH integrated client are applications that run on the switch. The SSH server works with the SSH client supported in this release and with non-Cisco SSH clients. The SSH client works with publicly and commercially available SSH servers. The SSH client supports the ciphers of Data Encryption Standard (DES), 3DES, and password authentication.

The switch supports an SSHv1 or an SSHv2 server.

The switch supports an SSHv1 client.



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**Note** The SSH client functionality is available only when the SSH server is enabled.

---

User authentication is performed like that in the Telnet session to the device. SSH also supports the following user authentication methods:

- TACACS+
- RADIUS
- Local authentication and authorization

### Related Topics

[Configuring the Switch for Local Authentication and Authorization](#), on page 1839

[TACACS+ and Switch Access](#), on page 1731

[RADIUS and Switch Access](#), on page 1785

## SSH Configuration Guidelines

Follow these guidelines when configuring the switch as an SSH server or SSH client:

- An RSA key pair generated by a SSHv1 server can be used by an SSHv2 server, and the reverse.
- If the SSH server is running on a stack master and the stack master fails, the new stack master uses the RSA key pair generated by the previous stack master.
- If you get CLI error messages after entering the **crypto key generate rsa** global configuration command, an RSA key pair has not been generated. Reconfigure the hostname and domain, and then enter the **crypto key generate rsa** command.
- When generating the RSA key pair, the message No host name specified might appear. If it does, you must configure a hostname by using the **hostname** global configuration command.
- When generating the RSA key pair, the message No domain specified might appear. If it does, you must configure an IP domain name by using the **ip domain-name** global configuration command.
- When configuring the local authentication and authorization authentication method, make sure that AAA is disabled on the console.

### Related Topics

[Setting Up the Device to Run SSH](#), on page 1847

[Configuring the Switch for Local Authentication and Authorization](#), on page 1839

## Secure Copy Protocol Overview

The Secure Copy Protocol (SCP) feature provides a secure and authenticated method for copying switch configurations or switch image files. SCP relies on Secure Shell (SSH), an application and a protocol that provides a secure replacement for the Berkeley r-tools.

For SSH to work, the switch needs an RSA public/private key pair. This is the same with SCP, which relies on SSH for its secure transport.

Because SSH also relies on AAA authentication, and SCP relies further on AAA authorization, correct configuration is necessary.

- Before enabling SCP, you must correctly configure SSH, authentication, and authorization on the switch.
- Because SCP relies on SSH for its secure transport, the router must have an Rivest, Shamir, and Adelman (RSA) key pair.



---

**Note** When using SCP, you cannot enter the password into the copy command. You must enter the password when prompted.

---

## Secure Copy Protocol

The Secure Copy Protocol (SCP) feature provides a secure and authenticated method for copying device configurations or switch image files. The behavior of SCP is similar to that of remote copy (rtp), which comes from the Berkeley r-tools suite, except that SCP relies on SSH for security. SCP also requires that authentication,

authorization, and accounting (AAA) authorization be configured so the device can determine whether the user has the correct privilege level. To configure the Secure Copy feature, you should understand the SCP concepts.

#### Related Topics

[Prerequisites for Configuring Secure Shell](#), on page 1843

[Restrictions for Configuring Secure Shell](#), on page 1844

# How to Configure SSH

## Setting Up the Device to Run SSH

Follow the procedure given below to set up your Device to run SSH:

#### Before you begin

Configure user authentication for local or remote access. This step is required. For more information, see Related Topics below.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>hostname <i>hostname</i></b> <b>Example:</b> Device(config)# <b>hostname your_hostname</b>	Configures a hostname and IP domain name for your Device. <p><b>Note</b> Follow this procedure only if you are configuring the Device as an SSH server.</p>
<b>Step 4</b>	<b>ip domain-name <i>domain_name</i></b> <b>Example:</b> Device(config)# <b>ip domain-name your_domain</b>	Configures a host domain for your Device.

	Command or Action	Purpose
<b>Step 5</b>	<b>crypto key generate rsa</b> <b>Example:</b> <pre>Device(config)# crypto key generate rsa</pre>	<p>Enables the SSH server for local and remote authentication on the Device and generates an RSA key pair. Generating an RSA key pair for the Device automatically enables SSH.</p> <p>We recommend that a minimum modulus size of 1024 bits.</p> <p>When you generate RSA keys, you are prompted to enter a modulus length. A longer modulus length might be more secure, but it takes longer to generate and to use.</p> <p><b>Note</b> Follow this procedure only if you are configuring the Device as an SSH server.</p>
<b>Step 6</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[SSH Configuration Guidelines](#), on page 1846

[Configuring the Switch for Local Authentication and Authorization](#), on page 1839

## Configuring the SSH Server

Follow the procedure given below to configure the SSH server:



**Note** This procedure is only required if you are configuring the Device as an SSH server.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip ssh version [1   2]</b> <b>Example:</b> Device(config)# <b>ip ssh version 1</b>	(Optional) Configures the Device to run SSH Version 1 or SSH Version 2. <ul style="list-style-type: none"> <li>• <b>1</b>—Configure the Device to run SSH Version 1.</li> <li>• <b>2</b>—Configure the Device to run SSH Version 2.</li> </ul> <p>If you do not enter this command or do not specify a keyword, the SSH server selects the latest SSH version supported by the SSH client. For example, if the SSH client supports SSHv1 and SSHv2, the SSH server selects SSHv2.</p>
<b>Step 4</b>	<b>ip ssh {timeout <i>seconds</i>   authentication-retries <i>number</i>}</b> <b>Example:</b> Device(config)# <b>ip ssh timeout 90 authentication-retries 2</b>	Configures the SSH control parameters: <ul style="list-style-type: none"> <li>• Specify the time-out value in seconds; the default is 120 seconds. The range is 0 to 120 seconds. This parameter applies to the SSH negotiation phase. After the connection is established, the Device uses the default time-out values of the CLI-based sessions.               <p>By default, up to five simultaneous, encrypted SSH connections for multiple CLI-based sessions over the network are available (session 0 to session 4). After the execution shell starts, the CLI-based session time-out value returns to the default of 10 minutes.</p> </li> <li>• Specify the number of times that a client can re-authenticate to the server. The default is 3; the range is 0 to 5.</li> </ul>

	Command or Action	Purpose
		Repeat this step when configuring both parameters.
<b>Step 5</b>	Use one or both of the following: <ul style="list-style-type: none"> <li>• <code>line vty line_number[ending_line_number]</code></li> <li>• <code>transport input ssh</code></li> </ul> <b>Example:</b> Device(config)# <code>line vty 1 10</code>  or Device(config-line)# <code>transport input ssh</code>	(Optional) Configures the virtual terminal line settings. <ul style="list-style-type: none"> <li>• Enters line configuration mode to configure the virtual terminal line settings. For <code>line_number</code> and <code>ending_line_number</code>, specify a pair of lines. The range is 0 to 15.</li> <li>• Specifies that the Device prevent non-SSH Telnet connections. This limits the router to only SSH connections.</li> </ul>
<b>Step 6</b>	<b>end</b>  <b>Example:</b>  Device(config-line)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show running-config</b>  <b>Example:</b>  Device# <code>show running-config</code>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Monitoring the SSH Configuration and Status

This table displays the SSH server configuration and status.

**Table 140: Commands for Displaying the SSH Server Configuration and Status**

Command	Purpose
<code>show ip ssh</code>	Shows the version and configuration information for the SSH server.
<code>show ssh</code>	Shows the status of the SSH server.



# Additional References for Configuring Secure Shell

## Related Documents

Related Topic	Document Title
Configuring Identity Control policies and Identity Service templates for Session Aware networking.	<a href="#">Session Aware Networking Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</a>
Configuring RADIUS, TACACS+, Secure Shell, 802.1X and AAA.	<a href="#">Securing User Services Configuration Guide Library, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</a>

## Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

## Standards and RFCs

Standard/RFC	Title
None	

## MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

## Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for Configuring Secure Shell

Release	Feature Information
Cisco IOS XE 3.2SE	This feature was introduced.
Cisco IOS XE Denali 16.3.1	<b>Note</b> Effective with Cisco IOS XE Denali 16.3.1, Secure Shell Version 1 (SSHv1) is not available in Cisco IOS Software.
Cisco IOS 15.2(1)E	<p>The Reverse SSH Enhancements feature, which is supported for SSH Version 1 and 2, provides an alternative way to configure reverse Secure Shell (SSH) so that separate lines do not need to be configured for every terminal or auxiliary line on which SSH must be enabled. This feature also eliminates the rotary-group limitation.</p> <p>This feature was supported on CAT4500-X, CAT4500E-SUP6E, CAT4500E-SUP6L-E, CAT4500E-SUP7E, CAT4500E-SUP7L-E.</p> <p>The following command was introduced: <b>ssh</b>.</p>



## CHAPTER 103

# X.509v3 Certificates for SSH Authentication

- [X.509v3 Certificates for SSH Authentication, on page 1853](#)
- [Information About X.509v3 Certificates for SSH Authentication, on page 1854](#)
- [How to Configure X.509v3 Certificates for SSH Authentication, on page 1854](#)
- [Configuration Examples for X.509v3 Certificates for SSH Authentication, on page 1858](#)
- [Additional References for X.509v3 Certificates for SSH Authentication, on page 1859](#)
- [Feature Information for X.509v3 Certificates for SSH Authentication, on page 1860](#)

## X.509v3 Certificates for SSH Authentication

The X.509v3 Certificates for secure shell (SSH) Authentication feature uses the X.509v3 digital certificates in server and user authentication at the SSH server side.

## Prerequisites for Digital Certificates for SSH Authentication

The Digital Certificates for SSH Authentication feature introduces the **ip ssh server algorithm authentication** command to replace the **ip ssh server authenticate user** command. If you use the **ip ssh server authenticate user** command, the following deprecation message is displayed.

```
Warning: SSH command accepted but this CLI will be deprecated soon. Please move to new CLI
"ip ssh server algorithm authentication". Please configure "default ip ssh server
authenticate user" to make CLI ineffective.
```

Use the **default ip ssh server authenticate user** command to remove the **ip ssh server authenticate user** command from effect. The IOS secure shell (SSH) server then starts using the **ip ssh server algorithm authentication** command.

## Restrictions for X.509v3 Certificates for SSH Authentication

The following restrictions are applicable for X.509v3 Certificate for SSH Authentication:

- The X.509v3 Certificates for SSH Authentication feature implementation is applicable only on the IOS secure shell (SSH) server side.
- IOS SSH server supports only the x509v3-ssh-rsa algorithm based certificate for server and user authentication on the IOS SSH server side.

The X.509v3 Certificate for SSH Authentication fails in the following conditions:

- When root certification authority is configured as a trustpoint on the device.
- When a client passes a certificate chain that leads to a self-signed root certificate authority that includes a client certificate, sub-ca certificate, and self-signed root certificate authority.
- When a sub-ca certification is configured as a trustpoint on the device but not included as a trustpoint on the user certificate.

## Information About X.509v3 Certificates for SSH Authentication

The following section provides information about digital certificates, and server and user authentication.

### Digital Certificates

The validity of the authentication depends upon the strength of the linkage between the public signing key and the identity of the signer. Digital certificates in the X.509v3 format (RFC5280) are used to provide identity management. A chain of signatures by a trusted root certification authority and its intermediate certificate authorities binds a given public signing key to a given digital identity.

Public key infrastructure (PKI) trustpoint helps manage the digital certificates. The association between the certificate and the trustpoint helps track the certificate. The trustpoint contains information about the certificate authority (CA), different identity parameters, and the digital certificate. Multiple trustpoints can be created to associate with different certificates.

### Server and User Authentication using X.509v3

For server authentication, the IOS secure shell (SSH) server sends its own certificate to the SSH client for verification. This server certificate is associated with the trustpoint configured in the server certificate profile (ssh-server-cert-profile-server configuration mode).

For user authentication, the SSH client sends the user's certificate to the IOS SSH server for verification. The SSH server validates the incoming user certificate using public key infrastructure (PKI) trustpoints configured in the server certificate profile (ssh-server-cert-profile-user configuration mode).

By default, certificate-based authentication is enabled for server and user at the IOS SSH server end.

## How to Configure X.509v3 Certificates for SSH Authentication

The following section provides information about how to configure X.509v3 Certificates for SSH Authentication.

### Configuring IOS SSH Server to Use Digital Certificates for Sever Authentication

The following section provides information about Configuring IOS SSH Server to Use Digital Certificates for Sever Authentication.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip ssh server algorithm hostkey</b> {x509v3-ssh-rsa [ssh-rsa]   ssh-rsa [x509v3-ssh-rsa]} <b>Example:</b> Device(config)# <b>ip ssh server algorithm</b> <b>hostkey x509v3-ssh-rsa</b>	Defines the order of host key algorithms. Only the configured algorithm is negotiated with the secure shell (SSH) client.  <b>Note</b> The IOS SSH server must have at least one configured host key algorithm: <ul style="list-style-type: none"> <li>• ssh-rsa – public key based authentication</li> <li>• x509v3-ssh-rsa – certificate-based authentication</li> </ul>
<b>Step 4</b>	<b>ip ssh server certificate profile</b> <b>Example:</b> Device(config)# <b>ip ssh server certificate</b> <b>profile</b>	Configures server certificate profile and user certificate profile and enters SSH certificate profile configuration mode.
<b>Step 5</b>	<b>server</b> <b>Example:</b> Device(ssh-server-cert-profile)# <b>server</b>	Configures server certificate profile and enters SSH server certificate profile server configuration mode.
<b>Step 6</b>	<b>trustpoint sign</b> <i>PKI-trustpoint-name</i> <b>Example:</b> Device(ssh-server-cert-profile-server)# <b>trustpoint sign trust1</b>	Attaches the public key infrastructure (PKI) trustpoint to the server certificate profile. The SSH server uses the certificate associated with this PKI trustpoint for server authentication.
<b>Step 7</b>	<b>ocsp-response include</b> <b>Example:</b> Device(ssh-server-cert-profile-server)# <b>ocsp-response include</b>	(Optional) Sends the Online Certificate Status Protocol (OCSP) response or OCSP stapling along with the server certificate.  <b>Note</b> By default the “no” form of this command is configured and no OCSP response is sent along with the server certificate.

	Command or Action	Purpose
<b>Step 8</b>	<b>end</b> <b>Example:</b> <pre>Device (ssh-server-cert-profile-server) # end</pre>	Exits SSH server certificate profile server configuration mode and enters privileged EXEC mode.

## Configuring IOS SSH Server to Verify User's Digital Certificate for User Authentication

The following section provides information about configuring IOS SSH Server to Verify User's Digital Certificate for User Authentication.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ip ssh server algorithm authentication</b> <b>{publickey   keyboard   password}</b> <b>Example:</b> <pre>Device(config)# ip ssh server algorithm authentication publickey</pre>	Defines the order of user authentication algorithms. Only the configured algorithm is negotiated with the secure shell (SSH) client. <b>Note</b> <ul style="list-style-type: none"> <li>The IOS SSH server must have at least one configured user authentication algorithm.</li> <li>To use the certificate method for user authentication, the <b>publickey</b> keyword must be configured.</li> <li>The <b>ip ssh server algorithm authentication</b> command replaces the <b>ip ssh server authenticate user</b> command.</li> </ul>
<b>Step 4</b>	<b>ip ssh server algorithm publickey</b> <b>{x509v3-ssh-rsa [ssh-rsa]   ssh-rsa</b> <b>[x509v3-ssh-rsa]}</b>	Defines the order of public key algorithms. Only the configured algorithm is accepted by the SSH client for user authentication.

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config)# ip ssh server algorithm publickey x509v3-ssh-rsa</pre>	<p><b>Note</b> The IOS SSH client must have at least one configured public key algorithm:</p> <ul style="list-style-type: none"> <li>• ssh-rsa – public-key-based authentication</li> <li>• x509v3-ssh-rsa – certificate-based authentication</li> </ul>
<b>Step 5</b>	<p><b>ip ssh server certificate profile</b></p> <p><b>Example:</b></p> <pre>Device(config)#ip ssh server certificate profile</pre>	Configures server certificate profile and user certificate profile and enters SSH certificate profile configuration mode.
<b>Step 6</b>	<p><b>user</b></p> <p><b>Example:</b></p> <pre>Device(ssh-server-cert-profile)# user</pre>	Configures user certificate profile and enters SSH server certificate profile user configuration mode.
<b>Step 7</b>	<p><b>trustpoint verify <i>PKI-trustpoint-name</i></b></p> <p><b>Example:</b></p> <pre>Device(ssh-server-cert-profile-user)#trustpoint verify trust2</pre>	<p>Configures the public key infrastructure (PKI) trustpoint that is used to verify the incoming user certificate.</p> <p><b>Note</b> Configure multiple trustpoints by executing the same command multiple times. A maximum of 10 trustpoints can be configured.</p>
<b>Step 8</b>	<p><b>ocsp-response required</b></p> <p><b>Example:</b></p> <pre>Device(ssh-server-cert-profile-user)# ocsp-response required</pre>	<p>(Optional) Mandates the presence of the Online Certificate Status Protocol (OCSP) response with the incoming user certificate.</p> <p><b>Note</b> By default the “no” form of this command is configured and the user certificate is accepted without an OCSP response.</p>
<b>Step 9</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(ssh-server-cert-profile-user)#end</pre>	Exits SSH server certificate profile user configuration mode and enters privileged EXEC mode.

## Verifying Configuration for Server and User Authentication Using Digital Certificates

The following section provides information about verifying configuration for Server and User Authentication Using Digital Certificates.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>show ip ssh</b> <b>Example:</b> Device# <b>show ip ssh</b>  SSH Enabled - version 1.99 Authentication methods:publickey,keyboard-interactive,password Authentication Publickey Algorithms:x509v3-ssh-rsa,ssh-rsa Hostkey Algorithms:x509v3-ssh-rsa,ssh-rsa Authentication timeout: 120 secs; Authentication retries: 3 Minimum expected Diffie Hellman key size : 1024 bits	Displays the currently configured authentication methods. To confirm the use of certificate-based authentication, ensure that the x509v3-ssh-rsa algorithm is the configured host key algorithm.

## Configuration Examples for X.509v3 Certificates for SSH Authentication

The following section provides examples for user and server authentication using digital certificates.

### Example: Configuring IOS SSH Server to Use Digital Certificates for Server Authentication

This example shows how to configure IOS SSH Server to Use Digital Certificates for Server Authentication.

```
Device> enable
Device# configure terminal
Device(config)# ip ssh server algorithm hostkey x509v3-ssh-rsa
Device(config)# ip ssh server certificate profile
```



```
Device(ssh-server-cert-profile)# server
Device(ssh-server-cert-profile-server)# trustpoint sign trust1
Device(ssh-server-cert-profile-server)# exit
```

## Example: Configuring IOS SSH Server to Verify User's Digital Certificate for User Authentication

This example shows how to configure IOS SSH Server to Verify User's Digital Certificate for User Authentication.

```
Device> enable
Device# configure terminal
Device(config)# ip ssh server algorithm authentication publickey
Device(config)# ip ssh server algorithm publickey x509v3-ssh-rsa
Device(config)# ip ssh server certificate profile
Device(ssh-server-cert-profile)# user
Device(ssh-server-cert-profile-user)# trustpoint verify trust2
Device(ssh-server-cert-profile-user)# end
```

## Additional References for X.509v3 Certificates for SSH Authentication

### Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Command List, All Releases
Security commands	<ul style="list-style-type: none"> <li>• Cisco IOS Security Command Reference: Commands A to C</li> <li>• Cisco IOS Security Command Reference: Commands D to L</li> <li>• Cisco IOS Security Command Reference: Commands M to R</li> <li>• Cisco IOS Security Command Reference: Commands S to Z</li> </ul>
SSH authentication	“Secure Shell-Configuring User Authentication Methods” chapter in <i>Secure Shell Configuration Guide</i>
Public key infrastructure (PKI) trustpoint	“Configuring and Managing a Cisco IOS Certificate Server for PKI Deployment” chapter in <i>Public Key Infrastructure Configuration Guide</i>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<p><a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a></p>

## Feature Information for X.509v3 Certificates for SSH Authentication

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

**Table 141: Feature Information for X.509v3 Certificates for SSH Authentication**

Feature Information	Release	Modification
X.509v3 Certificates for SSH Authentication	Cisco IOS XE Denali 16.1.x	The X.509v3 Certificates for SSH Authentication feature uses the X.509v3 digital certificates in server and user authentication at the secure shell (SSH) server side



## CHAPTER 104

# Configuring Secure Socket Layer HTTP

- [Finding Feature Information, on page 1861](#)
- [Information about Secure Sockets Layer \(SSL\) HTTP, on page 1861](#)
- [How to Configure Secure HTTP Servers and Clients, on page 1865](#)
- [Monitoring Secure HTTP Server and Client Status, on page 1871](#)
- [Additional References for Configuring Secure Shell, on page 1872](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information about Secure Sockets Layer (SSL) HTTP

### Secure HTTP Servers and Clients Overview

On a secure HTTP connection, data to and from an HTTP server is encrypted before being sent over the Internet. HTTP with SSL encryption provides a secure connection to allow such functions as configuring a switch from a Web browser. Cisco's implementation of the secure HTTP server and secure HTTP client uses an implementation of SSL Version 3.0 with application-layer encryption. HTTP over SSL is abbreviated as HTTPS; the URL of a secure connection begins with `https://` instead of `http://`.



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**Note** SSL evolved into Transport Layer Security (TLS) in 1999, but is still used in this particular context.

---

The primary role of the HTTP secure server (the switch) is to listen for HTTPS requests on a designated port (the default HTTPS port is 443) and pass the request to the HTTP 1.1 Web server. The HTTP 1.1 server

processes requests and passes responses (pages) back to the HTTP secure server, which, in turn, responds to the original request.

The primary role of the HTTP secure client (the web browser) is to respond to Cisco IOS application requests for HTTPS User Agent services, perform HTTPS User Agent services for the application, and pass the response back to the application.



---

**Note** Beginning with Cisco IOS XE Denali 16.3.1, support for attaching IPv6 ACL to the HTTP server has been enabled. Prior to Cisco IOS XE Denali 16.3.1, only IPv4 ACL support was available for configuring the secure HTTP server. You can attach the preconfigured IPv6 and IPv4 ACLs to the HTTP server using the configuration CLI for the secure HTTP server.

---

## Certificate Authority Trustpoints

Certificate authorities (CAs) manage certificate requests and issue certificates to participating network devices. These services provide centralized security key and certificate management for the participating devices. Specific CA servers are referred to as *trustpoints*.

When a connection attempt is made, the HTTPS server provides a secure connection by issuing a certified X.509v3 certificate, obtained from a specified CA trustpoint, to the client. The client (usually a Web browser), in turn, has a public key that allows it to authenticate the certificate.

For secure HTTP connections, we highly recommend that you configure a CA trustpoint. If a CA trustpoint is not configured for the device running the HTTPS server, the server certifies itself and generates the needed RSA key pair. Because a self-certified (self-signed) certificate does not provide adequate security, the connecting client generates a notification that the certificate is self-certified, and the user has the opportunity to accept or reject the connection. This option is useful for internal network topologies (such as testing).

If you do not configure a CA trustpoint, when you enable a secure HTTP connection, either a temporary or a persistent self-signed certificate for the secure HTTP server (or client) is automatically generated.

- If the switch is not configured with a hostname and a domain name, a temporary self-signed certificate is generated. If the switch reboots, any temporary self-signed certificate is lost, and a new temporary new self-signed certificate is assigned.
- If the switch has been configured with a host and domain name, a persistent self-signed certificate is generated. This certificate remains active if you reboot the switch or if you disable the secure HTTP server so that it will be there the next time you re-enable a secure HTTP connection.



---

**Note** The certificate authorities and trustpoints must be configured on each device individually. Copying them from other devices makes them invalid on the switch.

When a new certificate is enrolled, the new configuration change is not applied to the HTTPS server until the server is restarted. You can restart the server using either the CLI or by physical reboot. On restarting the server, the switch starts using the new certificate.

---

If a self-signed certificate has been generated, this information is included in the output of the **show running-config** privileged EXEC command. This is a partial sample output from that command displaying a self-signed certificate.

```

Device# show running-config
Building configuration...

<output truncated>

crypto pki trustpoint TP-self-signed-3080755072
  enrollment selfsigned
  subject-name cn=IOS-Self-Signed-Certificate-3080755072
  revocation-check none
  rsakeypair TP-self-signed-3080755072
  !
!
crypto ca certificate chain TP-self-signed-3080755072
certificate self-signed 01
  3082029F 30820208 A0030201 02020101 300D0609 2A864886 F70D0101 04050030
  59312F30 2D060355 04031326 494F532D 53656C66 2D536967 6E65642D 43657274
  69666963 6174652D 33303830 37353530 37323126 30240609 2A864886 F70D0109
  02161743 45322D33 3535302D 31332E73 756D6D30 342D3335 3530301E 170D3933
  30333031 30303030 35395A17 0D323030 31303130 30303030 305A3059 312F302D

<output truncated>

```

You can remove this self-signed certificate by disabling the secure HTTP server and entering the **no crypto pki trustpoint TP-self-signed-30890755072** global configuration command. If you later re-enable a secure HTTP server, a new self-signed certificate is generated.



**Note** The values that follow *TP self-signed* depend on the serial number of the device.

You can use an optional command (**ip http secure-client-auth**) to allow the HTTPS server to request an X.509v3 certificate from the client. Authenticating the client provides more security than server authentication by itself.

## CipherSuites

A CipherSuite specifies the encryption algorithm and the digest algorithm to use on a SSL connection. When connecting to the HTTPS server, the client Web browser offers a list of supported CipherSuites, and the client and server negotiate the best encryption algorithm to use from those on the list that are supported by both. For example, Netscape Communicator 4.76 supports U.S. security with RSA Public Key Cryptography, MD2, MD5, RC2-CBC, RC4, DES-CBC, and DES-EDE3-CBC.

For the best possible encryption, you should use a client browser that supports 128-bit encryption, such as Microsoft Internet Explorer Version 5.5 (or later) or Netscape Communicator Version 4.76 (or later). The `SSL_RSA_WITH_DES_CBC_SHA` CipherSuite provides less security than the other CipherSuites, as it does not offer 128-bit encryption.

The more secure and more complex CipherSuites require slightly more processing time. This list defines the CipherSuites supported by the switch and ranks them from fastest to slowest in terms of router processing load (speed):

1. `SSL_RSA_WITH_DES_CBC_SHA`—RSA key exchange (RSA Public Key Cryptography) with DES-CBC for message encryption and SHA for message digest
2. `SSL_RSA_WITH_NULL_SHA` key exchange with NULL for message encryption and SHA for message digest (only for SSL 3.0).

3. `SSL_RSA_WITH_NULL_MD5` key exchange with NULL for message encryption and MD5 for message digest (only for SSL 3.0).
4. `SSL_RSA_WITH_RC4_128_MD5`—RSA key exchange with RC4 128-bit encryption and MD5 for message digest
5. `SSL_RSA_WITH_RC4_128_SHA`—RSA key exchange with RC4 128-bit encryption and SHA for message digest
6. `SSL_RSA_WITH_3DES_EDE_CBC_SHA`—RSA key exchange with 3DES and DES-EDE3-CBC for message encryption and SHA for message digest
7. `SSL_RSA_WITH_AES_128_CBC_SHA`—RSA key exchange with AES 128-bit encryption and SHA for message digest (only for SSL 3.0).
8. `SSL_RSA_WITH_AES_256_CBC_SHA`—RSA key exchange with AES 256-bit encryption and SHA for message digest (only for SSL 3.0).
9. `SSL_RSA_WITH_DHE_AES_128_CBC_SHA`—RSA key exchange with AES 128-bit encryption and SHA for message digest (only for SSL 3.0).
10. `SSL_RSA_WITH_DHE_AES_256_CBC_SHA`—RSA key exchange with AES 256-bit encryption and SHA for message digest (only for SSL 3.0).



---

**Note** The latest versions of Chrome do not support the four original cipher suites, thus disallowing access to both web GUI and guest portals.

---

RSA (in conjunction with the specified encryption and digest algorithm combinations) is used for both key generation and authentication on SSL connections. This usage is independent of whether or not a CA trustpoint is configured.

## Default SSL Configuration

The standard HTTP server is enabled.

SSL is enabled.

No CA trustpoints are configured.

No self-signed certificates are generated.

## SSL Configuration Guidelines

When SSL is used in a switch cluster, the SSL session terminates at the cluster commander. Cluster member switches must run standard HTTP.

Before you configure a CA trustpoint, you should ensure that the system clock is set. If the clock is not set, the certificate is rejected due to an incorrect date.

In a switch stack, the SSL session terminates at the stack master.

# How to Configure Secure HTTP Servers and Clients

## Configuring a CA Trustpoint

For secure HTTP connections, we recommend that you configure an official CA trustpoint. A CA trustpoint is more secure than a self-signed certificate.

Beginning in privileged EXEC mode, follow these steps to configure a CA Trustpoint:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>hostname <i>hostname</i></b> <b>Example:</b>  Device (config)# <b>hostname your_hostname</b>	Specifies the hostname of the switch (required only if you have not previously configured a hostname). The hostname is required for security keys and certificates.
<b>Step 3</b>	<b>ip domain-name <i>domain-name</i></b> <b>Example:</b>  Device (config)# <b>ip domain-name your_domain</b>	Specifies the IP domain name of the switch (required only if you have not previously configured an IP domain name). The domain name is required for security keys and certificates.
<b>Step 4</b>	<b>crypto key generate rsa</b> <b>Example:</b>  Device (config)# <b>crypto key generate rsa</b>	(Optional) Generates an RSA key pair. RSA key pairs are required before you can obtain a certificate for the switch. RSA key pairs are generated automatically. You can use this command to regenerate the keys, if needed.
<b>Step 5</b>	<b>crypto ca trustpoint <i>name</i></b> <b>Example:</b>  Device (config)# <b>crypto ca trustpoint your_trustpoint</b>	Specifies a local configuration name for the CA trustpoint and enter CA trustpoint configuration mode.
<b>Step 6</b>	<b>enrollment url <i>url</i></b> <b>Example:</b>	Specifies the URL to which the switch should send certificate requests.

	Command or Action	Purpose
	<pre>Device(ca-trustpoint)# enrollment url http://your_server:80</pre>	
<b>Step 7</b>	<p><b>enrollment http-proxy</b> <i>host-name</i> <i>port-number</i></p> <p><b>Example:</b></p> <pre>Device(ca-trustpoint)# enrollment http-proxy your_host 49</pre>	<p>(Optional) Configures the switch to obtain certificates from the CA through an HTTP proxy server.</p> <ul style="list-style-type: none"> <li>• For <i>host-name</i>, specify the proxy server used to get the CA.</li> <li>• For <i>port-number</i>, specify the port number used to access the CA.</li> </ul>
<b>Step 8</b>	<p><b>crl query</b> <i>url</i></p> <p><b>Example:</b></p> <pre>Device(ca-trustpoint)# crl query ldap://your_host:49</pre>	<p>Configures the switch to request a certificate revocation list (CRL) to ensure that the certificate of the peer has not been revoked.</p>
<b>Step 9</b>	<p><b>primary</b> <i>name</i></p> <p><b>Example:</b></p> <pre>Device(ca-trustpoint)# primary your_trustpoint</pre>	<p>(Optional) Specifies that the trustpoint should be used as the primary (default) trustpoint for CA requests.</p> <ul style="list-style-type: none"> <li>• For <i>name</i>, specify the trustpoint that you just configured.</li> </ul>
<b>Step 10</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(ca-trustpoint)# exit</pre>	<p>Exits CA trustpoint configuration mode and return to global configuration mode.</p>
<b>Step 11</b>	<p><b>crypto ca authentication</b> <i>name</i></p> <p><b>Example:</b></p> <pre>Device(config)# crypto ca authentication your_trustpoint</pre>	<p>Authenticates the CA by getting the public key of the CA. Use the same name used in Step 5.</p>
<b>Step 12</b>	<p><b>crypto ca enroll</b> <i>name</i></p> <p><b>Example:</b></p> <pre>Device(config)# crypto ca enroll your_trustpoint</pre>	<p>Obtains the certificate from the specified CA trustpoint. This command requests a signed certificate for each RSA key pair.</p>
<b>Step 13</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	<p>Returns to privileged EXEC mode.</p>



## Configuring the Secure HTTP Server

Beginning in privileged EXEC mode, follow these steps to configure a secure HTTP server:

### Before you begin

If you are using a certificate authority for certification, you should use the previous procedure to configure the CA trustpoint on the switch before enabling the HTTP server. If you have not configured a CA trustpoint, a self-signed certificate is generated the first time that you enable the secure HTTP server. After you have configured the server, you can configure options (path, access list to apply, maximum number of connections, or timeout policy) that apply to both standard and secure HTTP servers.

To verify the secure HTTP connection by using a Web browser, enter `https://URL`, where the URL is the IP address or hostname of the server switch. If you configure a port other than the default port, you must also specify the port number after the URL. For example:



---

**Note** AES256\_SHA2 is not supported.

---

```
https://209.165.129.1026
```

or

```
https://host.domain.com:1026
```

The existing **ip http access-class** *access-list-number* command for specifying the access-list(Only IPv4 ACLs) is going to be deprecated. You can still use this command to specify an access list to allow access to the HTTP server. Two new commands have been introduced to enable support for specifying IPv4 and IPv6 ACLs.

These are **ip http access-class ipv4** *access-list-name* | *access-list-number* for specifying IPv4 ACLs and **ip http access-class ipv6** *access-list-name* for specifying IPv6 ACLs. We recommend using the new CLI to avoid receiving warning messages.

Note the following considerations for specifying access-lists:

- If you specify an access-list that does not exist, the configuration takes place but you receive the below warning message:

```
ACL being attached does not exist, please configure it
```

- If you use the **ip http access-class** command for specifying an access-list for the HTTP server, the below warning message appears:

```
This CLI will be deprecated soon, Please use new CLI ip http  
access-class ipv4/ipv6 <access-list-name>| <access-list-number>
```

- If you use **ip http access-class ipv4** *access-list-name* | *access-list-number* or **ip http access-class ipv6** *access-list-name* , and an access-list was already configured using **ip http access-class** , the below warning message appears:

```
Removing ip http access-class <access-list-number>
```

**ip http access-class** *access-list-number* and **ip http access-class ipv4** *access-list-name* | *access-list-number* share the same functionality. Each command overrides the configuration of the previous command. The

following combinations between the configuration of the two commands explain the effect on the running configuration:

- If **ip http access-class** *access-list-number* is already configured and you try to configure using **ip http access-class ipv4** *access-list-number* command, the configuration of **ip http access-class** *access-list-number* will be removed and the configuration of **ip http access-class ipv4** *access-list-number* will be added to the running configuration.
- If **ip http access-class** *access-list-number* is already configured and you try to configure using **ip http access-class ipv4** *access-list-name* command, the configuration of **ip http access-class** *access-list-number* will be removed and the configuration of **ip http access-class ipv4** *access-list-name* will be added to the running configuration.
- If **ip http access-class ipv4** *access-list-number* is already configured and you try to configure using **ip http access-class** *access-list-name*, the configuration of **ip http access-class ipv4** *access-list-number* will be removed from configuration and the configuration of **ip http access-class** *access-list-name* will be added to the running configuration.
- If **ip http access-class ipv4** *access-list-name* is already configured and you try to configure using **ip http access-class** *access-list-number*, the configuration of **ip http access-class ipv4** *access-list-name* will be removed from the configuration and the configuration of **ip http access-class** *access-list-number* will be added to the running configuration.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>show ip http server status</b> <b>Example:</b> <pre>Device# show ip http server status</pre>	(Optional) Displays the status of the HTTP server to determine if the secure HTTP server feature is supported in the software. You should see one of these lines in the output:  <pre>HTTP secure server capability: Present</pre> or  <pre>HTTP secure server capability: Not present</pre>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ip http secure-server</b> <b>Example:</b> <pre>Device(config)# ip http secure-server</pre>	Enables the HTTPS server if it has been disabled. The HTTPS server is enabled by default.

	Command or Action	Purpose
<b>Step 4</b>	<b>ip http secure-port</b> <i>port-number</i> <b>Example:</b> Device(config)# <b>ip http secure-port 443</b>	(Optional) Specifies the port number to be used for the HTTPS server. The default port number is 443. Valid options are 443 or any number in the range 1025 to 65535.
<b>Step 5</b>	<b>ip http secure-ciphersuite</b> {[3des-ede-cbc-sha] [rc4-128-md5] [rc4-128-sha] [des-cbc-sha]} <b>Example:</b> Device(config)# <b>ip http secure-ciphersuite rc4-128-md5</b>	(Optional) Specifies the CipherSuites (encryption algorithms) to be used for encryption over the HTTPS connection. If you do not have a reason to specify a particularly CipherSuite, you should allow the server and client to negotiate a CipherSuite that they both support. This is the default.
<b>Step 6</b>	<b>ip http secure-client-auth</b> <b>Example:</b> Device(config)# <b>ip http secure-client-auth</b>	(Optional) Configures the HTTP server to request an X.509v3 certificate from the client for authentication during the connection process. The default is for the client to request a certificate from the server, but the server does not attempt to authenticate the client.
<b>Step 7</b>	<b>ip http secure-trustpoint</b> <i>name</i> <b>Example:</b> Device(config)# <b>ip http secure-trustpoint your_trustpoint</b>	Specifies the CA trustpoint to use to get an X.509v3 security certificate and to authenticate the client certificate connection.  <b>Note</b> Use of this command assumes you have already configured a CA trustpoint according to the previous procedure.
<b>Step 8</b>	<b>ip http path</b> <i>path-name</i> <b>Example:</b> Device(config)# <b>ip http path /your_server:80</b>	(Optional) Sets a base HTTP path for HTML files. The path specifies the location of the HTTP server files on the local system (usually located in system flash memory).
<b>Step 9</b>	<b>ip http access-class</b> <i>access-list-number</i> <b>Example:</b> Device(config)# <b>ip http access-class 2</b>	(Optional) Specifies an access list to use to allow access to the HTTP server.
<b>Step 10</b>	<b>ip http access-class</b> { <b>ipv4</b> { <i>access-list-number</i>   <i>access-list-name</i> }   <b>ipv6</b> { <i>access-list-name</i> } } <b>Example:</b>	(Optional) Specifies an access list to use to allow access to the HTTP server.

	Command or Action	Purpose
	Device (config) # <code>ip http access-class ipv4 4</code>	
<b>Step 11</b>	<p><code>ip http max-connections value</code></p> <p><b>Example:</b></p> <pre>Device (config) # ip http max-connections 4</pre>	(Optional) Sets the maximum number of concurrent connections that are allowed to the HTTP server. We recommend that the value be at least 10 and not less. This is required for the UI to function as expected.
<b>Step 12</b>	<p><code>ip http timeout-policy idle seconds life seconds requests value</code></p> <p><b>Example:</b></p> <pre>Device (config) # ip http timeout-policy idle 120 life 240 requests 1</pre>	<p>(Optional) Specifies how long a connection to the HTTP server can remain open under the defined circumstances:</p> <ul style="list-style-type: none"> <li>• <b>idle</b>—the maximum time period when no data is received or response data cannot be sent. The range is 1 to 600 seconds. The default is 180 seconds (3 minutes).</li> <li>• <b>life</b>—the maximum time period from the time that the connection is established. The range is 1 to 86400 seconds (24 hours). The default is 180 seconds.</li> <li>• <b>requests</b>—the maximum number of requests processed on a persistent connection. The maximum value is 86400. The default is 1.</li> </ul>
<b>Step 13</b>	<p><code>end</code></p> <p><b>Example:</b></p> <pre>Device (config) # end</pre>	Returns to privileged EXEC mode.

## Configuring the Secure HTTP Client

Beginning in privileged EXEC mode, follow these steps to configure a secure HTTP client:

### Before you begin

The standard HTTP client and secure HTTP client are always enabled. A certificate authority is required for secure HTTP client certification. This procedure assumes that you have previously configured a CA trustpoint on the switch. If a CA trustpoint is not configured and the remote HTTPS server requires client authentication, connections to the secure HTTP client fail.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ip http client secure-trustpoint <i>name</i></b> <b>Example:</b> Device(config)# <code>ip http client secure-trustpoint your_trustpoint</code>	(Optional) Specifies the CA trustpoint to be used if the remote HTTP server requests client authentication. Using this command assumes that you have already configured a CA trustpoint by using the previous procedure. The command is optional if client authentication is not needed or if a primary trustpoint has been configured.
<b>Step 3</b>	<b>ip http client secure-ciphersuite</b> <b>{[3des-cde-cbc-sha] [rc4-128-md5]</b> <b>[rc4-128-sha] [des-cbc-sha]}</b> <b>Example:</b> Device(config)# <code>ip http client secure-ciphersuite rc4-128-md5</code>	(Optional) Specifies the CipherSuites (encryption algorithms) to be used for encryption over the HTTPS connection. If you do not have a reason to specify a particular CipherSuite, you should allow the server and client to negotiate a CipherSuite that they both support. This is the default.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.

## Monitoring Secure HTTP Server and Client Status

To monitor the SSL secure server and client status, use the privileged EXEC commands in the following table.

**Table 142: Commands for Displaying the SSL Secure Server and Client Status**

Command	Purpose
<code>show ip http client secure status</code>	Shows the HTTP secure client configuration.
<code>show ip http server secure status</code>	Shows the HTTP secure server configuration.
<code>show running-config</code>	Shows the generated self-signed certificate for secure HTTP connections.

# Additional References for Configuring Secure Shell

## Related Documents

Related Topic	Document Title
Configuring Identity Control policies and Identity Service templates for Session Aware networking.	<a href="#">Session Aware Networking Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</a>
Configuring RADIUS, TACACS+, Secure Shell, 802.1X and AAA.	<a href="#">Securing User Services Configuration Guide Library, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</a>

## Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

## Standards and RFCs

Standard/RFC	Title
None	

## MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

## Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>



## CHAPTER 105

# IPv4 ACLs

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- [Finding Feature Information, on page 1873](#)
- [Information about Network Security with ACLs, on page 1873](#)
- [Prerequisites for Configuring IPv4 Access Control Lists, on page 1886](#)
- [Restrictions for Configuring IPv4 Access Control Lists, on page 1886](#)
- [How to Configure ACLs, on page 1887](#)
- [Monitoring IPv4 ACLs, on page 1906](#)
- [Configuration Examples for ACLs, on page 1907](#)
- [Additional References, on page 1921](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information about Network Security with ACLs

This chapter describes how to configure network security on the switch by using access control lists (ACLs), which in commands and tables are also referred to as access lists.

## ACL Overview

Packet filtering can help limit network traffic and restrict network use by certain users or devices. ACLs filter traffic as it passes through a router or switch and permit or deny packets crossing specified interfaces or VLANs. An ACL is a sequential collection of permit and deny conditions that apply to packets. When a packet is received on an interface, the switch compares the fields in the packet against any applied ACLs to verify that the packet has the required permissions to be forwarded, based on the criteria specified in the access lists. One by one, it tests packets against the conditions in an access list. The first match decides whether the switch accepts or rejects the packets. Because the switch stops testing after the first match, the order of conditions

in the list is critical. If no conditions match, the switch rejects the packet. If there are no restrictions, the switch forwards the packet; otherwise, the switch drops the packet. The switch can use ACLs on all packets it forwards, including packets bridged within a VLAN.

You configure access lists on a router or Layer 3 switch to provide basic security for your network. If you do not configure ACLs, all packets passing through the switch could be allowed onto all parts of the network. You can use ACLs to control which hosts can access different parts of a network or to decide which types of traffic are forwarded or blocked at router interfaces. For example, you can allow e-mail traffic to be forwarded but not Telnet traffic. ACLs can be configured to block inbound traffic, outbound traffic, or both.

## Access Control Entries

An ACL contains an ordered list of access control entries (ACEs). Each ACE specifies *permit* or *deny* and a set of conditions the packet must satisfy in order to match the ACE. The meaning of *permit* or *deny* depends on the context in which the ACL is used.

## ACL Supported Types

The switch supports IP ACLs and Ethernet (MAC) ACLs:

- IP ACLs filter IPv4 traffic, including TCP, User Datagram Protocol (UDP), Internet Group Management Protocol (IGMP), and Internet Control Message Protocol (ICMP).
- Ethernet ACLs filter non-IP traffic.

This switch also supports quality of service (QoS) classification ACLs.

## Supported ACLs

The switch supports three types of ACLs to filter traffic:

- Port ACLs access-control traffic entering a Layer 2 interface. You can apply port ACLs to a Layer 2 interface in each direction to each access list type — IPv4 and MAC.
- Router ACLs access-control routed traffic between VLANs and are applied to Layer 3 interfaces in a specific direction (inbound or outbound).
- VLAN ACLs or VLAN maps access-control all packets (bridged and routed). You can use VLAN maps to filter traffic between devices in the same VLAN. VLAN maps are configured to provide access control based on Layer 3 addresses for IPv4. Unsupported protocols are access-controlled through MAC addresses using Ethernet ACEs. After a VLAN map is applied to a VLAN, all packets (routed or bridged) entering the VLAN are checked against the VLAN map. Packets can either enter the VLAN through a switch port or through a routed port after being routed.

## ACL Precedence

When VLAN maps, Port ACLs, and router ACLs are configured on the same switch, the filtering precedence, from greatest to least for ingress traffic is port ACL, VLAN map, and then router ACL. For egress traffic, the filtering precedence is router ACL, VLAN map, and then port ACL.

The following examples describe simple use cases:

- When both an input port ACL and a VLAN map are applied, incoming packets received on ports with a port ACL applied are filtered by the port ACL. Other packets are filtered by the VLAN map



- When an input router ACL and input port ACL exist in a switch virtual interface (SVI), incoming packets received on ports to which a port ACL is applied are filtered by the port ACL. Incoming routed IP packets received on other ports are filtered by the router ACL. Other packets are not filtered.
- When an output router ACL and input port ACL exist in an SVI, incoming packets received on the ports to which a port ACL is applied are filtered by the port ACL. Outgoing routed IP packets are filtered by the router ACL. Other packets are not filtered.
- When a VLAN map, input router ACL, and input port ACL exist in an SVI, incoming packets received on the ports to which a port ACL is applied are only filtered by the port ACL. Incoming routed IP packets received on other ports are filtered by both the VLAN map and the router ACL. Other packets are filtered only by the VLAN map.
- When a VLAN map, output router ACL, and input port ACL exist in an SVI, incoming packets received on the ports to which a port ACL is applied are only filtered by the port ACL. Outgoing routed IP packets are filtered by both the VLAN map and the router ACL. Other packets are filtered only by the VLAN map.

### Related Topics

[Restrictions for Configuring IPv4 Access Control Lists](#), on page 1886

## Port ACLs

Port ACLs are ACLs that are applied to Layer 2 interfaces on a switch. Port ACLs are supported only on physical interfaces and not on EtherChannel interfaces. Port ACLs can be applied to the interface in outbound and inbound direction. The following access lists are supported:

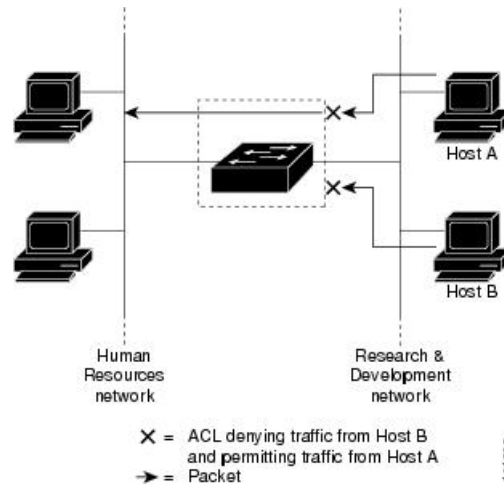
- Standard IP access lists using source addresses
- Extended IP access lists using source and destination addresses and optional protocol type information
- MAC extended access lists using source and destination MAC addresses and optional protocol type information

The switch examines ACLs on an interface and permits or denies packet forwarding based on how the packet matches the entries in the ACL. In this way, ACLs control access to a network or to part of a network.

### *Figure 110: Using ACLs to Control Traffic in a Network*

This is an example of using port ACLs to control access to a network when all workstations are in the same VLAN. ACLs applied at the Layer 2 input would allow Host A to access the Human Resources network, but

prevent Host B from accessing the same network. Port ACLs can only be applied to Layer 2 interfaces in the



inbound direction.

When you apply a port ACL to a trunk port, the ACL filters traffic on all VLANs present on the trunk port. When you apply a port ACL to a port with voice VLAN, the ACL filters traffic on both data and voice VLANs.

With port ACLs, you can filter IP traffic by using IP access lists and non-IP traffic by using MAC addresses. You can filter both IP and non-IP traffic on the same Layer 2 interface by applying both an IP access list and a MAC access list to the interface.



#### Note

You cannot apply more than one IP access list and one MAC access list to a Layer 2 interface. If an IP access list or MAC access list is already configured on a Layer 2 interface and you apply a new IP access list or MAC access list to the interface, the new ACL replaces the previously configured one.

## Router ACLs

You can apply router ACLs on switch virtual interfaces (SVIs), which are Layer 3 interfaces to VLANs; on physical Layer 3 interfaces; and on Layer 3 EtherChannel interfaces. You apply router ACLs on interfaces for specific directions (inbound or outbound). You can apply one router ACL in each direction on an interface.

The switch supports these access lists for IPv4 traffic:

- Standard IP access lists use source addresses for matching operations.
- Extended IP access lists use source and destination addresses and optional protocol type information for matching operations.

As with port ACLs, the switch examines ACLs associated with features configured on a given interface. As packets enter the switch on an interface, ACLs associated with all inbound features configured on that interface are examined. After packets are routed and before they are forwarded to the next hop, all ACLs associated with outbound features configured on the egress interface are examined.

ACLs permit or deny packet forwarding based on how the packet matches the entries in the ACL, and can be used to control access to a network or to part of a network.

## VLAN Maps

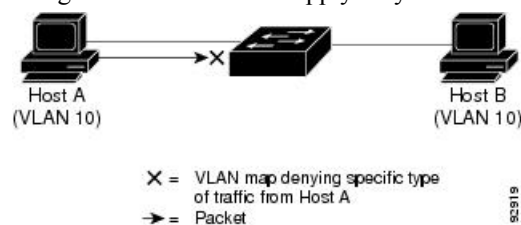
VLAN ACLs or VLAN maps are used to control network traffic within a VLAN. You can apply VLAN maps to all packets that are bridged within a VLAN in the switch or switch stack. VACLs are strictly for security packet filtering and for redirecting traffic to specific physical interfaces. VACLs are not defined by direction (ingress or egress).

All non-IP protocols are access-controlled through MAC addresses and Ethertype using MAC VLAN maps. (IP traffic is not access controlled by MAC VLAN maps.) You can enforce VLAN maps only on packets going through the switch; you cannot enforce VLAN maps on traffic between hosts on a hub or on another switch connected to this switch.

With VLAN maps, forwarding of packets is permitted or denied, based on the action specified in the map.

**Figure 111: Using VLAN Maps to Control Traffic**

This shows how a VLAN map is applied to prevent a specific type of traffic from Host A in VLAN 10 from being forwarded. You can apply only one VLAN map to a VLAN.



## ACEs and Fragmented and Unfragmented Traffic

IP packets can be fragmented as they cross the network. When this happens, only the fragment containing the beginning of the packet contains the Layer 4 information, such as TCP or UDP port numbers, ICMP type and code, and so on. All other fragments are missing this information.

Some access control entries (ACEs) do not check Layer 4 information and therefore can be applied to all packet fragments. ACEs that do test Layer 4 information cannot be applied in the standard manner to most of the fragments in a fragmented IP packet. When the fragment contains no Layer 4 information and the ACE tests some Layer 4 information, the matching rules are modified:

- Permit ACEs that check the Layer 3 information in the fragment (including protocol type, such as TCP, UDP, and so on) are considered to match the fragment regardless of what the missing Layer 4 information might have been.



**Note** For TCP ACEs with L4 Ops, the fragmented packets will be dropped per RFC 1858.

- Deny ACEs that check Layer 4 information never match a fragment unless the fragment contains Layer 4 information.

## ACEs and Fragmented and Unfragmented Traffic Examples

Consider access list 102, configured with these commands, applied to three fragmented packets:

```
Device(config)# access-list 102 permit tcp any host 10.1.1.1 eq smtp
Device(config)# access-list 102 deny tcp any host 10.1.1.2 eq telnet
Device(config)# access-list 102 permit tcp any host 10.1.1.2
Device(config)# access-list 102 deny tcp any any
```



**Note** In the first and second ACEs in the examples, the *eq* keyword after the destination address means to test for the TCP-destination-port well-known numbers equaling Simple Mail Transfer Protocol (SMTP) and Telnet, respectively.

- Packet A is a TCP packet from host 10.2.2.2., port 65000, going to host 10.1.1.1 on the SMTP port. If this packet is fragmented, the first fragment matches the first ACE (a permit) as if it were a complete packet because all Layer 4 information is present. The remaining fragments also match the first ACE, even though they do not contain the SMTP port information, because the first ACE only checks Layer 3 information when applied to fragments. The information in this example is that the packet is TCP and that the destination is 10.1.1.1.
- Packet B is from host 10.2.2.2, port 65001, going to host 10.1.1.2 on the Telnet port. If this packet is fragmented, the first fragment matches the second ACE (a deny) because all Layer 3 and Layer 4 information is present. The remaining fragments in the packet do not match the second ACE because they are missing Layer 4 information. Instead, they match the third ACE (a permit).

Because the first fragment was denied, host 10.1.1.2 cannot reassemble a complete packet, so packet B is effectively denied. However, the later fragments that are permitted will consume bandwidth on the network and resources of host 10.1.1.2 as it tries to reassemble the packet.

- Fragmented packet C is from host 10.2.2.2, port 65001, going to host 10.1.1.3, port ftp. If this packet is fragmented, the first fragment matches the fourth ACE (a deny). All other fragments also match the fourth ACE because that ACE does not check any Layer 4 information and because Layer 3 information in all fragments shows that they are being sent to host 10.1.1.3, and the earlier permit ACEs were checking different hosts.

## ACLs and Switch Stacks

ACL support is the same for a switch stack as for a standalone switch. ACL configuration information is propagated to all switches in the stack. All switches in the stack, including the active switch, process the information and program their hardware.

### Active Switch and ACL Functions

The active switch performs these ACL functions:

- It processes the ACL configuration and propagates the information to all stack members.
- It distributes the ACL information to any switch that joins the stack.
- If packets must be forwarded by software for any reason (for example, not enough hardware resources), the active switch forwards the packets only after applying ACLs on the packets.
- It programs its hardware with the ACL information it processes.

## Stack Member and ACL Functions

Stack members perform these ACL functions:

- They receive the ACL information from the active switch and program their hardware.
- A stack member configured as a standby switch, performs the functions of the active switch in the event the active switch fails.

## Active Switch Failure and ACLs

Both the active and standby switches have the ACL information. When the active switch fails, the standby takes over. The new active switch distributes the ACL information to all stack members.

## Standard and Extended IPv4 ACLs

This section describes IP ACLs.

An ACL is a sequential collection of permit and deny conditions. One by one, the switch tests packets against the conditions in an access list. The first match determines whether the switch accepts or rejects the packet. Because the switch stops testing after the first match, the order of the conditions is critical. If no conditions match, the switch denies the packet.

The software supports these types of ACLs or access lists for IPv4:

- Standard IP access lists use source addresses for matching operations.
- Extended IP access lists use source and destination addresses for matching operations and optional protocol-type information for finer granularity of control.

## IPv4 ACL Switch Unsupported Features

Configuring IPv4 ACLs on the switch is the same as configuring IPv4 ACLs on other Cisco switches and routers.

The following ACL-related features are not supported:

- Non-IP protocol ACLs
- IP accounting
- Reflexive ACLs and dynamic ACLs are not supported.

## Access List Numbers

The number you use to denote your ACL shows the type of access list that you are creating.

This lists the access-list number and corresponding access list type and shows whether or not they are supported in the switch. The switch supports IPv4 standard and extended access lists, numbers 1 to 199 and 1300 to 2699.

**Table 143: Access List Numbers**

Access List Number	Type	Supported
1–99	IP standard access list	Yes
100–199	IP extended access list	Yes
200–299	Protocol type-code access list	No
300–399	DECnet access list	No
400–499	XNS standard access list	No
500–599	XNS extended access list	No
600–699	AppleTalk access list	No
700–799	48-bit MAC address access list	No
800–899	IPX standard access list	No
900–999	IPX extended access list	No
1000–1099	IPX SAP access list	No
1100–1199	Extended 48-bit MAC address access list	No
1200–1299	IPX summary address access list	No
1300–1999	IP standard access list (expanded range)	Yes
2000–2699	IP extended access list (expanded range)	Yes

In addition to numbered standard and extended ACLs, you can also create standard and extended named IP ACLs by using the supported numbers. That is, the name of a standard IP ACL can be 1 to 99; the name of an extended IP ACL can be 100 to 199. The advantage of using named ACLs instead of numbered lists is that you can delete individual entries from a named list.

## Numbered Standard IPv4 ACLs

When creating an ACL, remember that, by default, the end of the ACL contains an implicit deny statement for all packets that it did not find a match for before reaching the end. With standard access lists, if you omit the mask from an associated IP host address ACL specification, 0.0.0.0 is assumed to be the mask.

The switch always rewrites the order of standard access lists so that entries with **host** matches and entries with matches having a *don't care* mask of 0.0.0.0 are moved to the top of the list, above any entries with

non-zero *don't care* masks. Therefore, in **show** command output and in the configuration file, the ACEs do not necessarily appear in the order in which they were entered.

After creating a numbered standard IPv4 ACL, you can apply it to VLANs, to terminal lines, or to interfaces.

## Numbered Extended IPv4 ACLs

Although standard ACLs use only source addresses for matching, you can use extended ACL source and destination addresses for matching operations and optional protocol type information for finer granularity of control. When you are creating ACEs in numbered extended access lists, remember that after you create the ACL, any additions are placed at the end of the list. You cannot reorder the list or selectively add or remove ACEs from a numbered list.

The switch does not support dynamic or reflexive access lists. It also does not support filtering based on the type of service (ToS) minimize-monetary-cost bit.

Some protocols also have specific parameters and keywords that apply to that protocol.

You can define an extended TCP, UDP, ICMP, IGMP, or other IP ACL. The switch also supports these IP protocols:



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**Note** ICMP echo-reply cannot be filtered. All other ICMP codes or types can be filtered.

---

These IP protocols are supported:

- Authentication Header Protocol (**ahp**)
- Encapsulation Security Payload (**esp**)
- Enhanced Interior Gateway Routing Protocol (**eigrp**)
- generic routing encapsulation (**gre**)
- Internet Control Message Protocol (**icmp**)
- Internet Group Management Protocol (**igmp**)
- any Interior Protocol (**ip**)
- IP in IP tunneling (**ipinip**)
- KA9Q NOS-compatible IP over IP tunneling (**nos**)
- Open Shortest Path First routing (**ospf**)
- Payload Compression Protocol (**pcp**)
- Protocol-Independent Multicast (**pim**)
- Transmission Control Protocol (**tcp**)
- User Datagram Protocol (**udp**)

## Named IPv4 ACLs

You can identify IPv4 ACLs with an alphanumeric string (a name) rather than a number. You can use named ACLs to configure more IPv4 access lists in a router than if you were to use numbered access lists. If you

identify your access list with a name rather than a number, the mode and command syntax are slightly different. However, not all commands that use IP access lists accept a named access list.



---

**Note** The name you give to a standard or extended ACL can also be a number in the supported range of access list numbers. That is, the name of a standard IP ACL can be 1 to 99 and . The advantage of using named ACLs instead of numbered lists is that you can delete individual entries from a named list.

---

Consider these guidelines before configuring named ACLs:

- Numbered ACLs are also available.
- A standard ACL and an extended ACL cannot have the same name.
- You can use standard or extended ACLs (named or numbered) in VLAN maps.

## ACL Logging

The switch software can provide logging messages about packets permitted or denied by a standard IP access list. That is, any packet that matches the ACL causes an informational logging message about the packet to be sent to the console. The level of messages logged to the console is controlled by the **logging console** commands controlling the syslog messages.



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**Note** ACL logging is only supported for RACL.

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**Note** Because routing is done in hardware and logging is done in software, if a large number of packets match a *permit* or *deny* ACE containing a **log** keyword, the software might not be able to match the hardware processing rate, and not all packets will be logged.

---

The first packet that triggers the ACL causes a logging message right away, and subsequent packets are collected over 5-minute intervals before they appear or logged. The logging message includes the access list number, whether the packet was permitted or denied, the source IP address of the packet, and the number of packets from that source permitted or denied in the prior 5-minute interval.



---

**Note** The logging facility might drop some logging message packets if there are too many to be handled or if there is more than one logging message to be handled in 1 second. This behavior prevents the router from crashing due to too many logging packets. Therefore, the logging facility should not be used as a billing tool or an accurate source of the number of matches to an access list.

---

## Hardware and Software Treatment of IP ACLs

ACL processing is performed in hardware. If the hardware reaches its capacity to store ACL configurations, all packets on that interface are dropped.





**Note** If an ACL configuration cannot be implemented in hardware due to an out-of-resource condition on a switch or stack member, then only the traffic in that VLAN arriving on that switch is affected.

For router ACLs, other factors can cause packets to be sent to the CPU:

- Using the **log** keyword
- Generating ICMP unreachable messages

When you enter the **show ip access-lists** privileged EXEC command, the match count displayed does not account for packets that are access controlled in hardware. Use the **show platform acl counters hardware** privileged EXEC command to obtain some basic hardware ACL statistics for switched and routed packets.

Router ACLs function as follows:

- The hardware controls permit and deny actions of standard and extended ACLs (input and output) for security access control.
- If **log** has not been specified, the flows that match a *deny* statement in a security ACL are dropped by the hardware if *ip unreachable* is disabled. The flows matching a *permit* statement are switched in hardware.
- Adding the **log** keyword to an ACE in a router ACL causes a copy of the packet to be sent to the CPU for logging only. If the ACE is a *permit* statement, the packet is still switched and routed in hardware.

## VLAN Map Configuration Guidelines

VLAN maps are the only way to control filtering within a VLAN. VLAN maps have no direction. To filter traffic in a specific direction by using a VLAN map, you need to include an ACL with specific source or destination addresses. If there is a match clause for that type of packet (IP or MAC) in the VLAN map, the default action is to drop the packet if the packet does not match any of the entries within the map. If there is no match clause for that type of packet, the default is to forward the packet.

The following are the VLAN map configuration guidelines:

- If there is no ACL configured to deny traffic on an interface and no VLAN map is configured, all traffic is permitted.
- Each VLAN map consists of a series of entries. The order of entries in an VLAN map is important. A packet that comes into the switch is tested against the first entry in the VLAN map. If it matches, the action specified for that part of the VLAN map is taken. If there is no match, the packet is tested against the next entry in the map.
- If the VLAN map has at least one match clause for the type of packet (IP or MAC) and the packet does not match any of these match clauses, the default is to drop the packet. If there is no match clause for that type of packet in the VLAN map, the default is to forward the packet.
- Logging is not supported for VLAN maps.
- When a switch has an IP access list or MAC access list applied to a Layer 2 interface, and you apply a VLAN map to a VLAN that the port belongs to, the port ACL takes precedence over the VLAN map.
- If a VLAN map configuration cannot be applied in hardware, all packets in that VLAN are dropped.

## VLAN Maps with Router ACLs

To access control both bridged and routed traffic, you can use VLAN maps only or a combination of router ACLs and VLAN maps. You can define router ACLs on both input and output routed VLAN interfaces, and you can define a VLAN map to access control the bridged traffic.

If a packet flow matches a VLAN-map deny clause in the ACL, regardless of the router ACL configuration, the packet flow is denied.




---

**Note** When you use router ACLs with VLAN maps, packets that require logging on the router ACLs are not logged if they are denied by a VLAN map.

---

If the VLAN map has a match clause for the type of packet (IP or MAC) and the packet does not match the type, the default is to drop the packet. If there is no match clause in the VLAN map, and no action specified, the packet is forwarded if it does not match any VLAN map entry.

## VLAN Maps and Router ACL Configuration Guidelines

These guidelines are for configurations where you need to have an router ACL and a VLAN map on the same VLAN. These guidelines do not apply to configurations where you are mapping router ACLs and VLAN maps on different VLANs.

If you must configure a router ACL and a VLAN map on the same VLAN, use these guidelines for both router ACL and VLAN map configuration:

- You can configure only one VLAN map and one router ACL in each direction (input/output) on a VLAN interface.
- Whenever possible, try to write the ACL with all entries having a single action except for the final, default action of the other type. That is, write the ACL using one of these two forms:  

```
permit... permit... permit... deny ip any any
```

or

```
deny... deny... deny... permit ip any any
```
- To define multiple actions in an ACL (permit, deny), group each action type together to reduce the number of entries.
- Avoid including Layer 4 information in an ACL; adding this information complicates the merging process. The best merge results are obtained if the ACLs are filtered based on IP addresses (source and destination) and not on the full flow (source IP address, destination IP address, protocol, and protocol ports). It is also helpful to use *don't care* bits in the IP address, whenever possible.

If you need to specify the full-flow mode and the ACL contains both IP ACEs and TCP/UDP/ICMP ACEs with Layer 4 information, put the Layer 4 ACEs at the end of the list. This gives priority to the filtering of traffic based on IP addresses.

## Time Ranges for ACLs

You can selectively apply extended ACLs based on the time of day and the week by using the **time-range** global configuration command. First, define a time-range name and set the times and the dates or the days of

the week in the time range. Then enter the time-range name when applying an ACL to set restrictions to the access list. You can use the time range to define when the permit or deny statements in the ACL are in effect, for example, during a specified time period or on specified days of the week. The **time-range** keyword and argument are referenced in the named and numbered extended ACL task tables.

These are some benefits of using time ranges:

- You have more control over permitting or denying a user access to resources, such as an application (identified by an IP address/mask pair and a port number).
- You can control logging messages. ACL entries can be set to log traffic only at certain times of the day. Therefore, you can simply deny access without needing to analyze many logs generated during peak hours.

Time-based access lists trigger CPU activity because the new configuration of the access list must be merged with other features and the combined configuration loaded into the hardware memory. For this reason, you should be careful not to have several access lists configured to take affect in close succession (within a small number of minutes of each other.)



---

**Note** The time range relies on the switch system clock; therefore, you need a reliable clock source. We recommend that you use Network Time Protocol (NTP) to synchronize the switch clock.

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#### Related Topics

[Configuring Time Ranges for ACLs](#), on page 1895

## IPv4 ACL Interface Considerations

When you apply the **ip access-group** interface configuration command to a Layer 3 interface (an SVI, a Layer 3 EtherChannel, or a routed port), the interface must have been configured with an IP address. Layer 3 access groups filter packets that are routed or are received by Layer 3 processes on the CPU. They do not affect packets bridged within a VLAN.

For inbound ACLs, after receiving a packet, the switch checks the packet against the ACL. If the ACL permits the packet, the switch continues to process the packet. If the ACL rejects the packet, the switch discards the packet.

For outbound ACLs, after receiving and routing a packet to a controlled interface, the switch checks the packet against the ACL. If the ACL permits the packet, the switch sends the packet. If the ACL rejects the packet, the switch discards the packet.

By default, the input interface sends ICMP Unreachable messages whenever a packet is discarded, regardless of whether the packet was discarded because of an ACL on the input interface or because of an ACL on the output interface. ICMP Unreachables are normally limited to no more than one every one-half second per input interface, but this can be changed by using the **ip icmp rate-limit unreachable** global configuration command.

When you apply an undefined ACL to an interface, the switch acts as if the ACL has not been applied to the interface and permits all packets. Remember this behavior if you use undefined ACLs for network security.

#### Related Topics

[Applying an IPv4 ACL to an Interface \(CLI\)](#), on page 1898

[Restrictions for Configuring IPv4 Access Control Lists](#), on page 1886

# Prerequisites for Configuring IPv4 Access Control Lists

This section lists the prerequisites for configuring network security with access control lists (ACLs).

- On switches running the LAN base feature set, VLAN maps are not supported.

# Restrictions for Configuring IPv4 Access Control Lists

## General Network Security

The following are restrictions for configuring network security with ACLs:

- Not all commands that accept a numbered ACL accept a named ACL. ACLs for packet filters and route filters on interfaces can use a name.
- A standard ACL and an extended ACL cannot have the same name.
- Though visible in the command-line help strings, **appletalk** is not supported as a matching condition for the **deny** and **permit** MAC access-list configuration mode commands.
- ACL wildcard is not supported in downstream client policy.

## IPv4 ACL Network Interfaces

The following restrictions apply to IPv4 ACLs to network interfaces:

- When controlling access to an interface, you can use a named or numbered ACL.
- If you apply an ACL to a Layer 2 interface that is a member of a VLAN, the Layer 2 (port) ACL takes precedence over an input Layer 3 ACL applied to the VLAN interface or a VLAN map applied to the VLAN.
- If you apply an ACL to a Layer 3 interface and routing is not enabled on the switch, the ACL only filters packets that are intended for the CPU, such as SNMP, Telnet, or web traffic.
- If the **preauth\_ipv4\_acl** ACL is configured to filter packets, the ACL is removed after authentication.
- You do not have to enable routing to apply ACLs to Layer 2 interfaces.



### Note

By default, the router sends Internet Control Message Protocol (ICMP) unreachable messages when a packet is denied by an access group on a Layer 3 interface. These access-group denied packets are not dropped in hardware but are bridged to the switch CPU so that it can generate the ICMP-unreachable message. They do not generate ICMP unreachable messages. ICMP unreachable messages can be disabled on router ACLs with the **no ip unreachable** interface command.

## MAC ACLs on a Layer 2 Interface

After you create a MAC ACL, you can apply it to a Layer 2 interface to filter non-IP traffic coming in that interface. When you apply the MAC ACL, consider these guidelines:

- You can apply no more than one IP access list and one MAC access list to the same Layer 2 interface. The IP access list filters only IP packets, and the MAC access list filters non-IP packets.
- A Layer 2 interface can have only one MAC access list. If you apply a MAC access list to a Layer 2 interface that has a MAC ACL configured, the new ACL replaces the previously configured one.



**Note** The `mac access-group` interface configuration command is only valid when applied to a physical Layer 2 interface. You cannot use the command on EtherChannel port channels.

### IP Access List Entry Sequence Numbering

- This feature does not support dynamic, reflexive, or firewall access lists.

### Related Topics

[Applying an IPv4 ACL to an Interface \(CLI\)](#), on page 1898

[IPv4 ACL Interface Considerations](#), on page 1885

[Creating Named MAC Extended ACLs](#), on page 1899

[Applying a MAC ACL to a Layer 2 Interface](#), on page 1901

## How to Configure ACLs

### Configuring IPv4 ACLs

Follow the procedure given below to use IP ACLs on the switch:

#### Procedure

- 
- Step 1** Create an ACL by specifying an access list number or name and the access conditions.
- Step 2** Apply the ACL to interfaces or terminal lines. You can also apply standard and extended IP ACLs to VLAN maps.
- 

### Creating a Numbered Standard ACL (CLI)

Follow the procedure given below to create a numbered standard ACL:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>enable</code> <b>Example:</b>	Enables privileged EXEC mode. Enter your password if prompted.

	Command or Action	Purpose
	Device> <b>enable</b>	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>access-list <i>access-list-number</i> {deny   permit} <i>source source-wildcard</i> [log]</b> <b>Example:</b> Device(config)# <b>access-list 2 deny your_host</b>	Defines a standard IPv4 access list by using a source address and wildcard. The <i>access-list-number</i> is a decimal number from 1 to 99 or 1300 to 1999. Enter <b>deny</b> or <b>permit</b> to specify whether to deny or permit access if conditions are matched. The <i>source</i> is the source address of the network or host from which the packet is being sent specified as: <ul style="list-style-type: none"> <li>• The 32-bit quantity in dotted-decimal format.</li> <li>• The keyword <b>any</b> as an abbreviation for <i>source</i> and <i>source-wildcard</i> of 0.0.0.0 255.255.255.255. You do not need to enter a source-wildcard.</li> <li>• The keyword <b>host</b> as an abbreviation for <i>source</i> and <i>source-wildcard</i> of <i>source</i> 0.0.0.0.</li> </ul> (Optional) The <i>source-wildcard</i> applies wildcard bits to the source. (Optional) Enter <b>log</b> to cause an informational logging message about the packet that matches the entry to be sent to the console. <b>Note</b> Logging is supported only on ACLs attached to Layer 3 interfaces.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b>	Verifies your entries.

	Command or Action	Purpose
	Device# <code>show running-config</code>	
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Configuring VLAN Maps](#), on page 1902

## Creating a Numbered Extended ACL (CLI)

Follow the procedure given below to create a numbered extended ACL:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>access-list <i>access-list-number</i> {deny   permit} <i>protocol source source-wildcard destination destination-wildcard</i> [<i>precedence precedence</i>] [<i>tos tos</i>] [<i>fragments</i>] [<i>log</i>] [<i>log-input</i>] [<i>time-range time-range-name</i>] [<i>dscp dscp</i>]</b> <b>Example:</b> Device(config)# <code>access-list 101 permit ip host 10.1.1.2 any precedence 0 tos 0 log</code>	Defines an extended IPv4 access list and the access conditions. The <i>access-list-number</i> is a decimal number from 100 to 199 or 2000 to 2699. Enter <b>deny</b> or <b>permit</b> to specify whether to deny or permit the packet if conditions are matched. For <i>protocol</i> , enter the name or number of an P protocol: <b>ahp</b> , <b>eigrp</b> , <b>esp</b> , <b>gre</b> , <b>icmp</b> , <b>igmp</b> , <b>igrp</b> , <b>ip</b> , <b>ipinip</b> , <b>nos</b> , <b>ospf</b> , <b>pcp</b> , <b>pim</b> , <b>tcp</b> , or <b>udp</b> , or an integer in the range 0 to 255 representing an IP protocol number. To match any Internet protocol (including ICMP, TCP, and UDP), use the keyword <b>ip</b> . <b>Note</b> This step includes options for most IP protocols. For additional specific parameters for TCP, UDP, ICMP, and IGMP, see the following steps.

	Command or Action	Purpose
		<p>The <i>source</i> is the number of the network or host from which the packet is sent.</p> <p>The <i>source-wildcard</i> applies wildcard bits to the source.</p> <p>The <i>destination</i> is the network or host number to which the packet is sent.</p> <p>The <i>destination-wildcard</i> applies wildcard bits to the destination.</p> <p>Source, source-wildcard, destination, and destination-wildcard can be specified as:</p> <ul style="list-style-type: none"> <li>• The 32-bit quantity in dotted-decimal format.</li> <li>• The keyword <b>any</b> for 0.0.0.0 255.255.255.255 (any host).</li> <li>• The keyword <b>host</b> for a single host 0.0.0.0.</li> </ul> <p>The other keywords are optional and have these meanings:</p> <ul style="list-style-type: none"> <li>• <b>precedence</b>—Enter to match packets with a precedence level specified as a number from 0 to 7 or by name: <b>routine</b> (0), <b>priority</b> (1), <b>immediate</b> (2), <b>flash</b> (3), <b>flash-override</b> (4), <b>critical</b> (5), <b>internet</b> (6), <b>network</b> (7).</li> <li>• <b>fragments</b>—Enter to check non-initial fragments.</li> <li>• <b>tos</b>—Enter to match by type of service level, specified by a number from 0 to 15 or a name: <b>normal</b> (0), <b>max-reliability</b> (2), <b>max-throughput</b> (4), <b>min-delay</b> (8).</li> <li>• <b>log</b>—Enter to create an informational logging message to be sent to the console about the packet that matches the entry or <b>log-input</b> to include the input interface in the log entry.</li> <li>• <b>time-range</b>—Specify the time-range name.</li> <li>• <b>dscp</b>—Enter to match packets with the DSCP value specified by a number from 0 to 63, or use the question mark (?) to see a list of available values.</li> </ul>



	Command or Action	Purpose
		<p><b>Note</b> If you enter a <b>dscp</b> value, you cannot enter <b>tos</b> or <b>precedence</b>. You can enter both a <b>tos</b> and a <b>precedence</b> value with no <b>dscp</b>.</p>
<b>Step 3</b>	<p><b>access-list</b> <i>access-list-number</i> {<b>deny</b>   <b>permit</b>}  <b>tcp</b> <i>source source-wildcard</i> [<i>operator port</i>]  <i>destination destination-wildcard</i> [<i>operator port</i>]  [<b>established</b>] [<b>precedence</b> <i>precedence</i>] [<b>tos</b>  <i>tos</i>] [<b>fragments</b>] [<b>log</b> [<b>log-input</b>] [<b>time-range</b>  <i>time-range-name</i>] [<b>dscp</b> <i>dscp</i>] [<i>flag</i>]</p> <p><b>Example:</b></p> <pre>Device(config)# access-list 101 permit tcp any any eq 500</pre>	<p>Defines an extended TCP access list and the access conditions.</p> <p>The parameters are the same as those described for an extended IPv4 ACL, with these exceptions:</p> <p>(Optional) Enter an <i>operator</i> and <i>port</i> to compare source (if positioned after <i>source source-wildcard</i>) or destination (if positioned after <i>destination destination-wildcard</i>) port. Possible operators include <b>eq</b> (equal), <b>gt</b> (greater than), <b>lt</b> (less than), <b>neq</b> (not equal), and <b>range</b> (inclusive range). Operators require a port number (range requires two port numbers separated by a space).</p> <p>Enter the <i>port</i> number as a decimal number (from 0 to 65535) or the name of a TCP port. Use only TCP port numbers or names when filtering TCP.</p> <p>The other optional keywords have these meanings:</p> <ul style="list-style-type: none"> <li>• <b>established</b>—Enter to match an established connection. This has the same function as matching on the <b>ack</b> or <b>rst</b> flag.</li> <li>• <i>flag</i>—Enter one of these flags to match by the specified TCP header bits: <b>ack</b> (acknowledge), <b>fin</b> (finish), <b>psh</b> (push), <b>rst</b> (reset), <b>syn</b> (synchronize), or <b>urg</b> (urgent).</li> </ul>
<b>Step 4</b>	<p><b>access-list</b> <i>access-list-number</i> {<b>deny</b>   <b>permit</b>}  <b>udp</b> <i>source source-wildcard</i> [<i>operator port</i>]  <i>destination destination-wildcard</i> [<i>operator port</i>]  [<b>precedence</b> <i>precedence</i>] [<b>tos</b> <i>tos</i>] [<b>fragments</b>]  [<b>log</b> [<b>log-input</b>] [<b>time-range</b> <i>time-range-name</i>]  [<b>dscp</b> <i>dscp</i>]</p> <p><b>Example:</b></p> <pre>Device(config)# access-list 101 permit udp any any eq 100</pre>	<p>(Optional) Defines an extended UDP access list and the access conditions.</p> <p>The UDP parameters are the same as those described for TCP except that the [<i>operator port</i>] port number or name must be a UDP port number or name, and the <b>flag</b> and <b>established</b> keywords are not valid for UDP.</p>

	Command or Action	Purpose
<b>Step 5</b>	<p><b>access-list</b> <i>access-list-number</i> {deny   permit} <b>icmp</b> <i>source source-wildcard destination destination-wildcard</i> [<i>icmp-type</i>   [<i>icmp-type icmp-code</i>]   [<i>icmp-message</i>]] [<b>precedence precedence</b>] [<b>tos tos</b>] [<b>fragments</b>] [<b>log</b>] [<b>log-input</b>] [<b>time-range time-range-name</b>] [<b>dscp dscp</b>]</p> <p><b>Example:</b></p> <pre>Device(config)# access-list 101 permit icmp any any 200</pre>	<p>Defines an extended ICMP access list and the access conditions.</p> <p>The ICMP parameters are the same as those described for most IP protocols in an extended IPv4 ACL, with the addition of the ICMP message type and code parameters. These optional keywords have these meanings:</p> <ul style="list-style-type: none"> <li>• <i>icmp-type</i>—Enter to filter by ICMP message type, a number from 0 to 255.</li> <li>• <i>icmp-code</i>—Enter to filter ICMP packets that are filtered by the ICMP message code type, a number from 0 to 255.</li> <li>• <i>icmp-message</i>—Enter to filter ICMP packets by the ICMP message type name or the ICMP message type and code name.</li> </ul>
<b>Step 6</b>	<p><b>access-list</b> <i>access-list-number</i> {deny   permit} <b>igmp</b> <i>source source-wildcard destination destination-wildcard</i> [<i>igmp-type</i>] [<b>precedence precedence</b>] [<b>tos tos</b>] [<b>fragments</b>] [<b>log</b>] [<b>log-input</b>] [<b>time-range time-range-name</b>] [<b>dscp dscp</b>]</p> <p><b>Example:</b></p> <pre>Device(config)# access-list 101 permit igmp any any 14</pre>	<p>(Optional) Defines an extended IGMP access list and the access conditions.</p> <p>The IGMP parameters are the same as those described for most IP protocols in an extended IPv4 ACL, with this optional parameter.</p> <p><i>igmp-type</i>—To match IGMP message type, enter a number from 0 to 15, or enter the message name: <b>dvmrp</b>, <b>host-query</b>, <b>host-report</b>, <b>pim</b>, or <b>trace</b>.</p>
<b>Step 7</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	<p>Returns to privileged EXEC mode.</p>

**Related Topics**

[Configuring VLAN Maps](#), on page 1902

## Creating Named Standard ACLs

Follow the procedure given below to create a standard ACL using names:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ip access-list standard <i>name</i></b> <b>Example:</b> <pre>Device(config)# ip access-list standard 20</pre>	Defines a standard IPv4 access list using a name, and enter access-list configuration mode.  The name can be a number from 1 to 99.
<b>Step 4</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>deny</b> {<i>source</i> [<i>source-wildcard</i>]   <b>host</b> <i>source</i>   <b>any</b>} [<b>log</b>]</li> <li>• <b>permit</b> {<i>source</i> [<i>source-wildcard</i>]   <b>host</b> <i>source</i>   <b>any</b>} [<b>log</b>]</li> </ul> <b>Example:</b> <pre>Device(config-std-nacl)# deny 192.168.0.0 0.0.255.255 255.255.0.0 0.0.255.255</pre> <p>or</p> <pre>Device(config-std-nacl)# permit 10.108.0.0 0.0.0.0 255.255.255.0 0.0.0.0</pre>	In access-list configuration mode, specify one or more conditions denied or permitted to decide if the packet is forwarded or dropped. <ul style="list-style-type: none"> <li>• <b>host</b> <i>source</i>—A source and source wildcard of <i>source</i> 0.0.0.0.</li> <li>• <b>any</b>—A source and source wildcard of 0.0.0.0 255.255.255.255.</li> </ul>
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config-std-nacl)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Verifies your entries.

	Command or Action	Purpose
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Creating Extended Named ACLs

Follow the procedure given below to create an extended ACL using names:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ip access-list extended <i>name</i></b> <b>Example:</b> <pre>Device(config)# ip access-list extended 150</pre>	Defines an extended IPv4 access list using a name, and enter access-list configuration mode. The name can be a number from 100 to 199.
<b>Step 4</b>	<pre>{deny   permit} protocol {source [source-wildcard]   host source   any} {destination [destination-wildcard]   host destination   any} [precedence precedence] [<i>tos tos</i>] [established] [log] [time-range time-range-name]</pre> <b>Example:</b> <pre>Device(config-ext-nacl)# permit 0 any any</pre>	In access-list configuration mode, specify the conditions allowed or denied. Use the <b>log</b> keyword to get access list logging messages, including violations. <ul style="list-style-type: none"> <li>• <b>host source</b>—A source and source wildcard of <i>source</i> 0.0.0.0.</li> <li>• <b>host destination</b>—A destination and destination wildcard of <i>destination</i> 0.0.0.0.</li> <li>• <b>any</b>—A source and source wildcard or destination and destination wildcard of 0.0.0.0 255.255.255.255.</li> </ul>

	Command or Action	Purpose
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-ext-nacl) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

When you are creating extended ACLs, remember that, by default, the end of the ACL contains an implicit deny statement for everything if it did not find a match before reaching the end. For standard ACLs, if you omit the mask from an associated IP host address access list specification, 0.0.0.0 is assumed to be the mask.

After you create an ACL, any additions are placed at the end of the list. You cannot selectively add ACL entries to a specific ACL. However, you can use **no permit** and **no deny** access-list configuration mode commands to remove entries from a named ACL.

Being able to selectively remove lines from a named ACL is one reason you might use named ACLs instead of numbered ACLs.

#### What to do next

After creating a named ACL, you can apply it to interfaces or to VLANs .

## Configuring Time Ranges for ACLs

Follow these steps to configure a time-range parameter for an ACL:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device(config) # <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>time-range <i>time-range-name</i></b> <b>Example:</b> Device(config)# <b>time-range workhours</b>	Assigns a meaningful name (for example, <i>workhours</i> ) to the time range to be created, and enter time-range configuration mode. The name cannot contain a space or quotation mark and must begin with a letter.
<b>Step 4</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>absolute</b> [<i>start time date</i>] [<i>end time date</i>]</li> <li>• <b>periodic</b> <i>day-of-the-week hh:mm to [day-of-the-week] hh:mm</i></li> <li>• <b>periodic</b> {<i>weekdays</i>   <i>weekend</i>   <i>daily</i>} <i>hh:mm to hh:mm</i></li> </ul> <b>Example:</b> Device(config-time-range)# <b>absolute start</b> 00:00 1 Jan 2006 <b>end</b> 23:59 1 Jan 2006  or  Device(config-time-range)# <b>periodic</b> <b>weekdays 8:00 to 12:00</b>	Specifies when the function it will be applied to is operational. <ul style="list-style-type: none"> <li>• You can use only one <b>absolute</b> statement in the time range. If you configure more than one absolute statement, only the one configured last is executed.</li> <li>• You can enter multiple <b>periodic</b> statements. For example, you could configure different hours for weekdays and weekends.</li> </ul> See the example configurations.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

**What to do next**

Repeat the steps if you have multiple items that you want in effect at different times.

**Related Topics**

[Time Ranges for ACLs](#), on page 1884

## Applying an IPv4 ACL to a Terminal Line

You can use numbered ACLs to control access to one or more terminal lines. You cannot apply named ACLs to lines. You must set identical restrictions on all the virtual terminal lines because a user can attempt to connect to any of them.

Follow these steps to restrict incoming and outgoing connections between a virtual terminal line and the addresses in an ACL:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device(config)# <b>enable</b>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>line [console   vty] line-number</b> <b>Example:</b> Device(config)# <b>line console 0</b>	Identifies a specific line to configure, and enter in-line configuration mode. <ul style="list-style-type: none"> <li>• <b>console</b>—Specifies the console terminal line. The console port is DCE.</li> <li>• <b>vtty</b>—Specifies a virtual terminal for remote console access.</li> </ul> <p>The <i>line-number</i> is the first line number in a contiguous group that you want to configure when the line type is specified. The range is from 0 to 16.</p>
<b>Step 4</b>	<b>access-class access-list-number {in   out}</b> <b>Example:</b> Device(config-line)# <b>access-class 10 in</b>	Restricts incoming and outgoing connections between a particular virtual terminal line (into a device) and the addresses in an access list.

	Command or Action	Purpose
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device (config-line)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Applying an IPv4 ACL to an Interface (CLI)

This section describes how to apply IPv4 ACLs to network interfaces.

Beginning in privileged EXEC mode, follow the procedure given below to control access to an interface:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device (config)# <b>interface gigabitethernet1/0/1</b>	Identifies a specific interface for configuration, and enter interface configuration mode.  The interface can be a Layer 2 interface (port ACL), or a Layer 3 interface (router ACL).
<b>Step 3</b>	<b>ip access-group {<i>access-list-number</i>   <i>name</i>} {in   out}</b> <b>Example:</b>  Device (config-if)# <b>ip access-group 2 in</b>	Controls access to the specified interface.



	Command or Action	Purpose
<b>Step 4</b>	<b>end</b> <b>Example:</b> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Displays the access list configuration.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[IPv4 ACL Interface Considerations](#), on page 1885

[Restrictions for Configuring IPv4 Access Control Lists](#), on page 1886

## Creating Named MAC Extended ACLs

You can filter non-IPv4 traffic on a VLAN or on a Layer 2 interface by using MAC addresses and named MAC extended ACLs. The procedure is similar to that of configuring other extended named ACLs.

Follow these steps to create a named MAC extended ACL:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>mac access-list extended <i>name</i></b> <b>Example:</b>	Defines an extended MAC access list using a name.

	Command or Action	Purpose
	Device(config)# <b>mac access-list extended mac1</b>	
<b>Step 4</b>	<p>{deny   permit} {any   host source MAC address   source MAC address mask} {any   host destination MAC address   destination MAC address mask} [type mask   lsap lsap mask   aarp   amber   dec-spanning   decnet-iv   diagnostic   dsm   etype-6000   etype-8042   lat   larc-sca   mop-console   mop-dump   msdos   mumps   netbios   vines-echo   vines-ip   xns-idp   0-65535] [cos cos]</p> <p><b>Example:</b></p> <pre>Device(config-ext-macl)# deny any any decnet-iv</pre> <p>OR</p> <pre>Device(config-ext-macl)# permit any any</pre>	<p>In extended MAC access-list configuration mode, specifies to <b>permit</b> or <b>deny</b> any source MAC address, a source MAC address with a mask, or a specific <b>host</b> source MAC address and <b>any</b> destination MAC address, destination MAC address with a mask, or a specific destination MAC address.</p> <p>(Optional) You can also enter these options:</p> <ul style="list-style-type: none"> <li>• <i>type mask</i>—An arbitrary EtherType number of a packet with Ethernet II or SNAP encapsulation in decimal, hexadecimal, or octal with optional mask of <i>don't care</i> bits applied to the EtherType before testing for a match.</li> <li>• <i>lsap lsap mask</i>—An LSAP number of a packet with IEEE 802.2 encapsulation in decimal, hexadecimal, or octal with optional mask of <i>don't care</i> bits.</li> <li>• <i>aarp   amber   dec-spanning   decnet-iv   diagnostic   dsm   etype-6000   etype-8042   lat   larc-sca   mop-console   mop-dump   msdos   mumps   netbios   vines-echo   vines-ip   xns-idp</i>—A non-IP protocol.</li> <li>• <i>cos cos</i>—An IEEE 802.1Q cost of service number from 0 to 7 used to set priority.</li> </ul>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-ext-macl)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 7</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Device# <code>copy running-config startup-config</code>	

### Related Topics

[Restrictions for Configuring IPv4 Access Control Lists](#), on page 1886

[Configuring VLAN Maps](#), on page 1902

## Applying a MAC ACL to a Layer 2 Interface

Follow these steps to apply a MAC access list to control access to a Layer 2 interface:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device(config)# <code>interface gigabitethernet1/0/2</code>	Identifies a specific interface, and enter interface configuration mode. The interface must be a physical Layer 2 interface (port ACL).
<b>Step 4</b>	<b>mac access-group {name} {in   out }</b> <b>Example:</b>  Device(config-if)# <code>mac access-group mac1 in</code>	Controls access to the specified interface by using the MAC access list.  Port ACLs are supported in the outbound and inbound directions .
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config-if)# <code>end</code>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 6</b>	<b>show mac access-group</b> [ <i>interface interface-id</i> ]  <b>Example:</b>  Device# <b>show mac access-group interface gigabitethernet1/0/2</b>	Displays the MAC access list applied to the interface or all Layer 2 interfaces.
<b>Step 7</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 8</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.

After receiving a packet, the switch checks it against the inbound ACL. If the ACL permits it, the switch continues to process the packet. If the ACL rejects the packet, the switch discards it. When you apply an undefined ACL to an interface, the switch acts as if the ACL has not been applied and permits all packets. Remember this behavior if you use undefined ACLs for network security.

#### Related Topics

[Restrictions for Configuring IPv4 Access Control Lists](#), on page 1886

## Configuring VLAN Maps

Follow the procedure given below to create a VLAN map and apply it to one or more VLANs:

#### Before you begin

Create the standard or extended IPv4 ACLs or named MAC extended ACLs that you want to apply to the VLAN.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>vlan access-map</b> <i>name</i> [ <i>number</i> ]  <b>Example:</b>  Device(config)# <b>vlan access-map map_1 20</b>	Creates a VLAN map, and give it a name and (optionally) a number. The number is the sequence number of the entry within the map.  When you create VLAN maps with the same name, numbers are assigned sequentially in increments of 10. When modifying or deleting maps, you can enter the number of the map entry that you want to modify or delete.

	Command or Action	Purpose
		<p>VLAN maps do not use the specific permit or deny keywords. To deny a packet by using VLAN maps, create an ACL that would match the packet, and set the action to drop. A permit in the ACL counts as a match. A deny in the ACL means no match.</p> <p>Entering this command changes to access-map configuration mode.</p>
<b>Step 2</b>	<p><b>match</b> {ip   mac} address {name   number} [name   number]</p> <p><b>Example:</b></p> <pre>Device(config-access-map) # match ip address ip2</pre>	<p>Match the packet (using either the IP or MAC address) against one or more standard or extended access lists. Note that packets are only matched against access lists of the correct protocol type. IP packets are matched against standard or extended IP access lists. Non-IP packets are only matched against named MAC extended access lists.</p> <p><b>Note</b> If the VLAN map is configured with a match clause for a type of packet (IP or MAC) and the map action is drop, all packets that match the type are dropped. If the VLAN map has no match clause, and the configured action is drop, all IP and Layer 2 packets are dropped.</p>
<b>Step 3</b>	<p>Enter one of the following commands to specify an IP packet or a non-IP packet (with only a known MAC address) and to match the packet against one or more ACLs (standard or extended):</p> <ul style="list-style-type: none"> <li>• <b>action</b> { forward}</li> </ul> <pre>Device(config-access-map) # action forward</pre> <ul style="list-style-type: none"> <li>• <b>action</b> { drop}</li> </ul> <pre>Device(config-access-map) # action drop</pre>	<p>Sets the action for the map entry.</p>
<b>Step 4</b>	<p><b>vlan filter</b> mapname vlan-list list</p> <p><b>Example:</b></p> <pre>Device(config) # vlan filter map 1 vlan-list 20-22</pre>	<p>Applies the VLAN map to one or more VLAN IDs.</p> <p>The list can be a single VLAN ID (22), a consecutive list (10-22), or a string of VLAN</p>

	Command or Action	Purpose
		IDs (12, 22, 30). Spaces around the comma and hyphen are optional.

**Related Topics**

[Creating a Numbered Standard ACL \(CLI\)](#), on page 1887

[Creating a Numbered Extended ACL \(CLI\)](#), on page 1889

[Creating Named MAC Extended ACLs](#), on page 1899

[Creating a VLAN Map](#), on page 1904

[Applying a VLAN Map to a VLAN](#), on page 1905

## Creating a VLAN Map

Each VLAN map consists of an ordered series of entries. Beginning in privileged EXEC mode, follow these steps to create, add to, or delete a VLAN map entry:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>vlan access-map <i>name</i> [<i>number</i>]</b>  <b>Example:</b>  Device(config)# <code>vlan access-map map_1 20</code>	<p>Creates a VLAN map, and give it a name and (optionally) a number. The number is the sequence number of the entry within the map.</p> <p>When you create VLAN maps with the same name, numbers are assigned sequentially in increments of 10. When modifying or deleting maps, you can enter the number of the map entry that you want to modify or delete.</p> <p>VLAN maps do not use the specific permit or deny keywords. To deny a packet by using VLAN maps, create an ACL that would match the packet, and set the action to drop. A permit in the ACL counts as a match. A deny in the ACL means no match.</p> <p>Entering this command changes to access-map configuration mode.</p>
<b>Step 3</b>	<b>match {ip   mac} address {<i>name</i>   <i>number</i>}</b> <b>[<i>name</i>   <i>number</i>]</b>  <b>Example:</b>	Match the packet (using either the IP or MAC address) against one or more standard or extended access lists. Note that packets are only matched against access lists of the correct

	Command or Action	Purpose
	<pre>Device(config-access-map) # match ip address ip2</pre>	protocol type. IP packets are matched against standard or extended IP access lists. Non-IP packets are only matched against named MAC extended access lists.
<b>Step 4</b>	<b>action {drop   forward}</b> <b>Example:</b> <pre>Device(config-access-map) # action forward</pre>	(Optional) Sets the action for the map entry. The default is to forward.
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config-access-map) # end</pre>	Returns to global configuration mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Displays the access list configuration.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Configuring VLAN Maps](#), on page 1902

## Applying a VLAN Map to a VLAN

Beginning in privileged EXEC mode, follow the procedure given below to apply a VLAN map to one or more VLANs:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>		
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>vlan filter</b> <i>mapname</i> <b>vlan-list</b> <i>list</i> <b>Example:</b> <pre>Device(config)# vlan filter map 1 vlan-list 20-22</pre>	Applies the VLAN map to one or more VLAN IDs.  The list can be a single VLAN ID (22), a consecutive list (10-22), or a string of VLAN IDs (12, 22, 30). Spaces around the comma and hyphen are optional.
<b>Step 4</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Displays the access list configuration.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Configuring VLAN Maps](#), on page 1902

## Monitoring IPv4 ACLs

You can monitor IPv4 ACLs by displaying the ACLs that are configured on the switch, and displaying the ACLs that have been applied to interfaces and VLANs.

When you use the **ip access-group** interface configuration command to apply ACLs to a Layer 2 or 3 interface, you can display the access groups on the interface. You can also display the MAC ACLs applied to a Layer 2 interface. You can use the privileged EXEC commands as described in this table to display this information.

**Table 144: Commands for Displaying Access Lists and Access Groups**

Command	Purpose
<b>show access-lists</b> [ <i>number</i>   <i>name</i> ]	Displays the contents of one or all current IP and MAC address access lists or a specific access list (numbered or named).
<b>show ip access-lists</b> [ <i>number</i>   <i>name</i> ]	Displays the contents of all current IP access lists or a specific IP access list (numbered or named).



Command	Purpose
<b>show ip interface</b> <i>interface-id</i>	Displays detailed configuration and status of an interface. If IP is enabled on the interface and ACLs have been applied by using the <b>ip access-group</b> interface configuration command, the access groups are included in the display.
<b>show running-config</b> [ <b>interface</b> <i>interface-id</i> ]	Displays the contents of the configuration file for the switch or the specified interface, including all configured MAC and IP access lists and which access groups are applied to an interface.
<b>show mac access-group</b> [ <b>interface</b> <i>interface-id</i> ]	Displays MAC access lists applied to all Layer 2 interfaces or the specified Layer 2 interface.

## Configuration Examples for ACLs

### Examples: Using Time Ranges with ACLs

This example shows how to verify after you configure time ranges for *workhours* and to configure January 1, 2006, as a company holiday.

```
Device# show time-range
time-range entry: new_year_day_2003 (inactive)
  absolute start 00:00 01 January 2006 end 23:59 01 January 2006
time-range entry: workhours (inactive)
  periodic weekdays 8:00 to 12:00
  periodic weekdays 13:00 to 17:00
```

To apply a time range, enter the time-range name in an extended ACL that can implement time ranges. This example shows how to create and verify extended access list 188 that denies TCP traffic from any source to any destination during the defined holiday times and permits all TCP traffic during work hours.

```
Device(config)# access-list 188 deny tcp any any time-range new_year_day_2006
Device(config)# access-list 188 permit tcp any any time-range workhours
Device(config)# end
Device# show access-lists
Extended IP access list 188
  10 deny tcp any any time-range new_year_day_2006 (inactive)
  20 permit tcp any any time-range workhours (inactive)
```

This example uses named ACLs to permit and deny the same traffic.

```
Device(config)# ip access-list extended deny_access
Device(config-ext-nacl)# deny tcp any any time-range new_year_day_2006
Device(config-ext-nacl)# exit
Device(config)# ip access-list extended may_access
Device(config-ext-nacl)# permit tcp any any time-range workhours
```

```

Device(config-ext-nacl)# end
Device# show ip access-lists
Extended IP access list lpip_default
 10 permit ip any any
Extended IP access list deny_access
 10 deny tcp any any time-range new_year_day_2006 (inactive)
Extended IP access list may_access
 10 permit tcp any any time-range workhours (inactive)

```

## Examples: Including Comments in ACLs

You can use the **remark** keyword to include comments (remarks) about entries in any IP standard or extended ACL. The remarks make the ACL easier for you to understand and scan. Each remark line is limited to 100 characters.

The remark can go before or after a permit or deny statement. You should be consistent about where you put the remark so that it is clear which remark describes which permit or deny statement. For example, it would be confusing to have some remarks before the associated permit or deny statements and some remarks after the associated statements.

To include a comment for IP numbered standard or extended ACLs, use the **access-list** *access-list number* **remark** *remark* global configuration command. To remove the remark, use the **no** form of this command.

In this example, the workstation that belongs to Jones is allowed access, and the workstation that belongs to Smith is not allowed access:

```

Device(config)# access-list 1 remark Permit only Jones workstation through
Device(config)# access-list 1 permit 171.69.2.88
Device(config)# access-list 1 remark Do not allow Smith through
Device(config)# access-list 1 deny 171.69.3.13

```

For an entry in a named IP ACL, use the **remark** access-list configuration command. To remove the remark, use the **no** form of this command.

In this example, the Jones subnet is not allowed to use outbound Telnet:

```

Device(config)# ip access-list extended telnetting
Device(config-ext-nacl)# remark Do not allow Jones subnet to telnet out
Device(config-ext-nacl)# deny tcp host 171.69.2.88 any eq telnet

```

## IPv4 ACL Configuration Examples

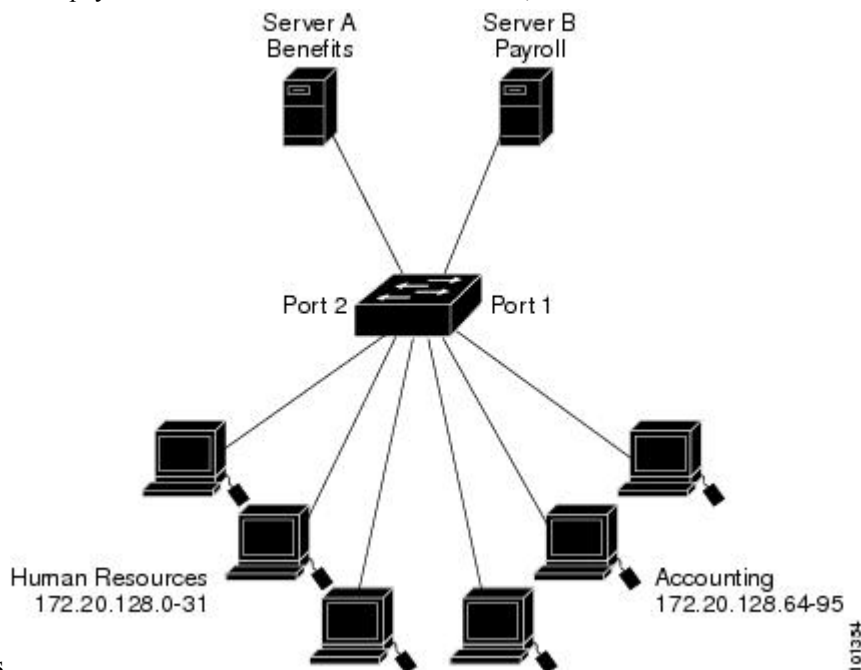
This section provides examples of configuring and applying IPv4 ACLs. For detailed information about compiling ACLs, see the *Cisco IOS Security Configuration Guide, Release 12.4* and to the “Configuring IP Services” section in the “IP Addressing and Services” chapter of the *Cisco IOS IP Configuration Guide, Release 12.4*.

### ACLs in a Small Networked Office

*Figure 112: Using Router ACLs to Control Traffic*

This shows a small networked office environment with routed Port 2 connected to Server A, containing benefits and other information that all employees can access, and routed Port 1 connected to Server B, containing

confidential payroll data. All users can access Server A, but Server B has restricted



access.

Use router ACLs to do this in one of two ways:

- Create a standard ACL, and filter traffic coming to the server from Port 1.
- Create an extended ACL, and filter traffic coming from the server into Port 1.

## Examples: ACLs in a Small Networked Office

This example uses a standard ACL to filter traffic coming into Server B from a port, permitting traffic only from Accounting's source addresses 172.20.128.64 to 172.20.128.95. The ACL is applied to traffic coming out of routed Port 1 from the specified source address.

```
Device(config)# access-list 6 permit 172.20.128.64 0.0.0.31
Device(config)# end
Device# show access-lists
Standard IP access list 6
 10 permit 172.20.128.64, wildcard bits 0.0.0.31
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip access-group 6 out
```

This example uses an extended ACL to filter traffic coming from Server B into a port, permitting traffic from any source address (in this case Server B) to only the Accounting destination addresses 172.20.128.64 to 172.20.128.95. The ACL is applied to traffic going into routed Port 1, permitting it to go only to the specified destination addresses. Note that with extended ACLs, you must enter the protocol (IP) before the source and destination information.

```
Device(config)# access-list 106 permit ip any 172.20.128.64 0.0.0.31
Device(config)# end
Device# show access-lists
Extended IP access list 106
```

```

10 permit ip any 172.20.128.64 0.0.0.31
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip access-group 106 in

```

## Example: Numbered ACLs

In this example, network 10.0.0.0 is a Class A network whose second octet specifies a subnet; that is, its subnet mask is 255.255.0.0. The third and fourth octets of a network 10.0.0.0 address specify a particular host. Using access list 2, the switch accepts one address on subnet 48 and reject all others on that subnet. The last line of the list shows that the switch accepts addresses on all other network 10.0.0.0 subnets. The ACL is applied to packets entering a port.

```

Device(config)# access-list 2 permit 10.48.0.3
Device(config)# access-list 2 deny 10.48.0.0 0.0.255.255
Device(config)# access-list 2 permit 10.0.0.0 0.255.255.255
Device(config)# interface gigabitethernet2/0/1
Device(config-if)# ip access-group 2 in

```

## Examples: Extended ACLs

In this example, the first line permits any incoming TCP connections with destination ports greater than 1023. The second line permits incoming TCP connections to the Simple Mail Transfer Protocol (SMTP) port of host 128.88.1.2. The third line permits incoming ICMP messages for error feedback.

```

Device(config)# access-list 102 permit tcp any 128.88.0.0 0.0.255.255 gt 1023
Device(config)# access-list 102 permit tcp any host 128.88.1.2 eq 25
Device(config)# access-list 102 permit icmp any any
Device(config)# interface gigabitethernet2/0/1
Device(config-if)# ip access-group 102 in

```

In this example, suppose that you have a network connected to the Internet, and you want any host on the network to be able to form TCP connections to any host on the Internet. However, you do not want IP hosts to be able to form TCP connections to hosts on your network, except to the mail (SMTP) port of a dedicated mail host.

SMTP uses TCP port 25 on one end of the connection and a random port number on the other end. The same port numbers are used throughout the life of the connection. Mail packets coming in from the Internet have a destination port of 25. Outbound packets have the port numbers reversed. Because the secure system of the network always accepts mail connections on port 25, the incoming and outgoing services are separately controlled. The ACL must be configured as an input ACL on the outbound interface and an output ACL on the inbound interface.

```

Device(config)# access-list 102 permit tcp any 128.88.0.0 0.0.255.255 eq 23
Device(config)# access-list 102 permit tcp any 128.88.0.0 0.0.255.255 eq 25
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip access-group 102 in

```

In this example, the network is a Class B network with the address 128.88.0.0, and the mail host address is 128.88.1.2. The **established** keyword is used only for the TCP to show an established connection. A match occurs if the TCP datagram has the ACK or RST bits set, which show that the packet belongs to an existing connection. Gigabit Ethernet interface 1 on stack member 1 is the interface that connects the router to the Internet.

```
Device(config)# access-list 102 permit tcp any 128.88.0.0 0.0.255.255 established
Device(config)# access-list 102 permit tcp any host 128.88.1.2 eq 25
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip access-group 102 in
```

## Examples: Named ACLs

### Creating named standard and extended ACLs

This example creates a standard ACL named *internet\_filter* and an extended ACL named *marketing\_group*. The *internet\_filter* ACL allows all traffic from the source address 1.2.3.4.

```
Device(config)# ip access-list standard Internet_filter
Device(config-ext-nacl)# permit 1.2.3.4
Device(config-ext-nacl)# exit
```

The *marketing\_group* ACL allows any TCP Telnet traffic to the destination address and wildcard 171.69.0.0 0.0.255.255 and denies any other TCP traffic. It permits ICMP traffic, denies UDP traffic from any source to the destination address range 171.69.0.0 through 179.69.255.255 with a destination port less than 1024, denies any other IP traffic, and provides a log of the result.

```
Device(config)# ip access-list extended marketing_group
Device(config-ext-nacl)# permit tcp any 171.69.0.0 0.0.255.255 eq telnet
Device(config-ext-nacl)# deny tcp any any
Device(config-ext-nacl)# permit icmp any any
Device(config-ext-nacl)# deny udp any 171.69.0.0 0.0.255.255 lt 1024
Device(config-ext-nacl)# deny ip any any log
Device(config-ext-nacl)# exit
```

The *Internet\_filter* ACL is applied to outgoing traffic and the *marketing\_group* ACL is applied to incoming traffic on a Layer 3 port.

```
Device(config)# interface gigabitethernet3/0/1
Device(config-if)# no switchport
Device(config-if)# ip address 2.0.5.1 255.255.255.0
Device(config-if)# ip access-group Internet_filter out
Device(config-if)# ip access-group marketing_group in
```

### Deleting individual ACEs from named ACLs

This example shows how you can delete individual ACEs from the named access list *border-list*:

```
Device(config)# ip access-list extended border-list
Device(config-ext-nacl)# no permit ip host 10.1.1.3 any
```

## Examples: Time Range Applied to an IP ACL

This example denies HTTP traffic on IP on Monday through Friday between the hours of 8:00 a.m. and 6:00 p.m. (18:00). The example allows UDP traffic only on Saturday and Sunday from noon to 8:00 p.m. (20:00).

```

Device(config)# time-range no-http
Device(config)# periodic weekdays 8:00 to 18:00
!
Device(config)# time-range udp-yes
Device(config)# periodic weekend 12:00 to 20:00
!
Device(config)# ip access-list extended strict
Device(config-ext-nacl)# deny tcp any any eq www time-range no-http
Device(config-ext-nacl)# permit udp any any time-range udp-yes
!
Device(config-ext-nacl)# exit
Device(config)# interface gigabitethernet2/0/1
Device(config-if)# ip access-group strict in

```

## Examples: Configuring Commented IP ACL Entries

In this example of a numbered ACL, the workstation that belongs to Jones is allowed access, and the workstation that belongs to Smith is not allowed access:

```

Device(config)# access-list 1 remark Permit only Jones workstation through
Device(config)# access-list 1 permit 171.69.2.88
Device(config)# access-list 1 remark Do not allow Smith workstation through
Device(config)# access-list 1 deny 171.69.3.13

```

In this example of a numbered ACL, the Winter and Smith workstations are not allowed to browse the web:

```

Device(config)# access-list 100 remark Do not allow Winter to browse the web
Device(config)# access-list 100 deny host 171.69.3.85 any eq www
Device(config)# access-list 100 remark Do not allow Smith to browse the web
Device(config)# access-list 100 deny host 171.69.3.13 any eq www

```

In this example of a named ACL, the Jones subnet is not allowed access:

```

Device(config)# ip access-list standard prevention
Device(config-std-nacl)# remark Do not allow Jones subnet through
Device(config-std-nacl)# deny 171.69.0.0 0.0.255.255

```

In this example of a named ACL, the Jones subnet is not allowed to use outbound Telnet:

```

Device(config)# ip access-list extended telnetting
Device(config-ext-nacl)# remark Do not allow Jones subnet to telnet out
Device(config-ext-nacl)# deny tcp 171.69.0.0 0.0.255.255 any eq telnet

```

## Examples: ACL Logging

Two variations of logging are supported on ACLs. The **log** keyword sends an informational logging message to the console about the packet that matches the entry; the **log-input** keyword includes the input interface in the log entry.

In this example, standard named access list *stan1* denies traffic from 10.1.1.0 0.0.0.255, allows traffic from all other sources, and includes the **log** keyword.

```

Device(config)# ip access-list standard stan1
Device(config-std-nacl)# deny 10.1.1.0 0.0.0.255 log
Device(config-std-nacl)# permit any log
Device(config-std-nacl)# exit
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip access-group stan1 in
Device(config-if)# end
Device# show logging
Syslog logging: enabled (0 messages dropped, 0 flushes, 0 overruns)
  Console logging: level debugging, 37 messages logged
  Monitor logging: level debugging, 0 messages logged
  Buffer logging: level debugging, 37 messages logged
  File logging: disabled
  Trap logging: level debugging, 39 message lines logged

Log Buffer (4096 bytes):

00:00:48: NTP: authentication delay calculation problems

<output truncated>

00:09:34:%SEC-6-IPACCESSLOGS:list stan1 permitted 0.0.0.0 1 packet
00:09:59:%SEC-6-IPACCESSLOGS:list stan1 denied 10.1.1.15 1 packet
00:10:11:%SEC-6-IPACCESSLOGS:list stan1 permitted 0.0.0.0 1 packet

```

This example is a named extended access list *ext1* that permits ICMP packets from any source to 10.1.1.0 0.0.0.255 and denies all UDP packets.

```

Device(config)# ip access-list extended ext1
Device(config-ext-nacl)# permit icmp any 10.1.1.0 0.0.0.255 log
Device(config-ext-nacl)# deny udp any any log
Device(config-ext-nacl)# exit
Device(config)# interface gigabitethernet1/0/2
Device(config-if)# ip access-group ext1 in

```

This is an example of a log for an extended ACL:

```

01:24:23:%SEC-6-IPACCESSLOGDP:list ext1 permitted icmp 10.1.1.15 -> 10.1.1.61 (0/0), 1
packet
01:25:14:%SEC-6-IPACCESSLOGDP:list ext1 permitted icmp 10.1.1.15 -> 10.1.1.61 (0/0), 7
packets
01:26:12:%SEC-6-IPACCESSLOGP:list ext1 denied udp 0.0.0.0(0) -> 255.255.255.255(0), 1 packet
01:31:33:%SEC-6-IPACCESSLOGP:list ext1 denied udp 0.0.0.0(0) -> 255.255.255.255(0), 8 packets

```

Note that all logging entries for IP ACLs start with %SEC-6-IPACCESSLOG with minor variations in format depending on the kind of ACL and the access entry that has been matched.

This is an example of an output message when the **log-input** keyword is entered:

```

00:04:21:%SEC-6-IPACCESSLOGDP:list inputlog permitted icmp 10.1.1.10 (Vlan1 0001.42ef.a400)
->
10.1.1.61 (0/0), 1 packet

```

A log message for the same sort of packet using the **log** keyword does not include the input interface information:

```
00:05:47:%SEC-6-IPACCESSLOGDP:list inputlog permitted icmp 10.1.1.10 -> 10.1.1.61 (0/0), 1
packet
```

## Configuration Examples for ACLs and VLAN Maps

### Example: Creating an ACL and a VLAN Map to Deny a Packet

This example shows how to create an ACL and a VLAN map to deny a packet. In the first map, any packets that match the *ip1* ACL (TCP packets) would be dropped. You first create the *ip1* ACL to permit any TCP packet and no other packets. Because there is a match clause for IP packets in the VLAN map, the default action is to drop any IP packet that does not match any of the match clauses.

```
Device(config)# ip access-list extended ip1
Device(config-ext-nacl)# permit tcp any any
Device(config-ext-nacl)# exit
Device(config)# vlan access-map map_1 10
Device(config-access-map)# match ip address ip1
Device(config-access-map)# action drop
```

### Example: Creating an ACL and a VLAN Map to Permit a Packet

This example shows how to create a VLAN map to permit a packet. ACL *ip2* permits UDP packets and any packets that match the *ip2* ACL are forwarded. In this map, any IP packets that did not match any of the previous ACLs (that is, packets that are not TCP packets or UDP packets) would get dropped.

```
Device(config)# ip access-list extended ip2
Device(config-ext-nacl)# permit udp any any
Device(config-ext-nacl)# exit
Device(config)# vlan access-map map_1 20
Device(config-access-map)# match ip address ip2
Device(config-access-map)# action forward
```

### Example: Default Action of Dropping IP Packets and Forwarding MAC Packets

In this example, the VLAN map has a default action of drop for IP packets and a default action of forward for MAC packets. Used with standard ACL 101 and extended named access lists **igmp-match** and **tcp-match**, the map will have the following results:

- Forward all UDP packets
- Drop all IGMP packets
- Forward all TCP packets
- Drop all other IP packets
- Forward all non-IP packets

```
Device(config)# access-list 101 permit udp any any
Device(config)# ip access-list extended igmp-match
Device(config-ext-nacl)# permit igmp any any

Device(config)# action forward
```



```

Device(config-ext-nacl)# permit tcp any any
Device(config-ext-nacl)# exit
Device(config)# vlan access-map drop-ip-default 10
Device(config-access-map)# match ip address 101
Device(config-access-map)# action forward
Device(config-access-map)# exit
Device(config)# vlan access-map drop-ip-default 20
Device(config-access-map)# match ip address igmp-match
Device(config-access-map)# action drop
Device(config-access-map)# exit
Device(config)# vlan access-map drop-ip-default 30
Device(config-access-map)# match ip address tcp-match
Device(config-access-map)# action forward

```

## Example: Default Action of Dropping MAC Packets and Forwarding IP Packets

In this example, the VLAN map has a default action of drop for MAC packets and a default action of forward for IP packets. Used with MAC extended access lists **good-hosts** and **good-protocols**, the map will have the following results:

- Forward MAC packets from hosts 0000.0c00.0111 and 0000.0c00.0211
- Forward MAC packets with decnet-iv or vines-ip protocols
- Drop all other non-IP packets
- Forward all IP packets

```

Device(config)# mac access-list extended good-hosts
Device(config-ext-nacl)# permit host 000.0c00.0111 any
Device(config-ext-nacl)# permit host 000.0c00.0211 any
Device(config-ext-nacl)# exit
Device(config)# action forward
Device(config-ext-nacl)# mac access-list extended good-protocols
Device(config-ext-nacl)# permit any any vines-ip
Device(config-ext-nacl)# exit
Device(config)# vlan access-map drop-mac-default 10
Device(config-access-map)# match mac address good-hosts
Device(config-access-map)# action forward
Device(config-access-map)# exit
Device(config)# vlan access-map drop-mac-default 20
Device(config-access-map)# match mac address good-protocols
Device(config-access-map)# action forward

```

## Example: Default Action of Dropping All Packets

In this example, the VLAN map has a default action of drop for all packets (IP and non-IP). Used with access lists **tcp-match** and **good-hosts** from Examples 2 and 3, the map will have the following results:

- Forward all TCP packets
- Forward MAC packets from hosts 0000.0c00.0111 and 0000.0c00.0211
- Drop all other IP packets
- Drop all other MAC packets

```

Device(config)# vlan access-map drop-all-default 10

```

```

Device(config-access-map)# match ip address tcp-match
Device(config-access-map)# action forward
Device(config-access-map)# exit
Device(config)# vlan access-map drop-all-default 20
Device(config-access-map)# match mac address good-hosts
Device(config-access-map)# action forward

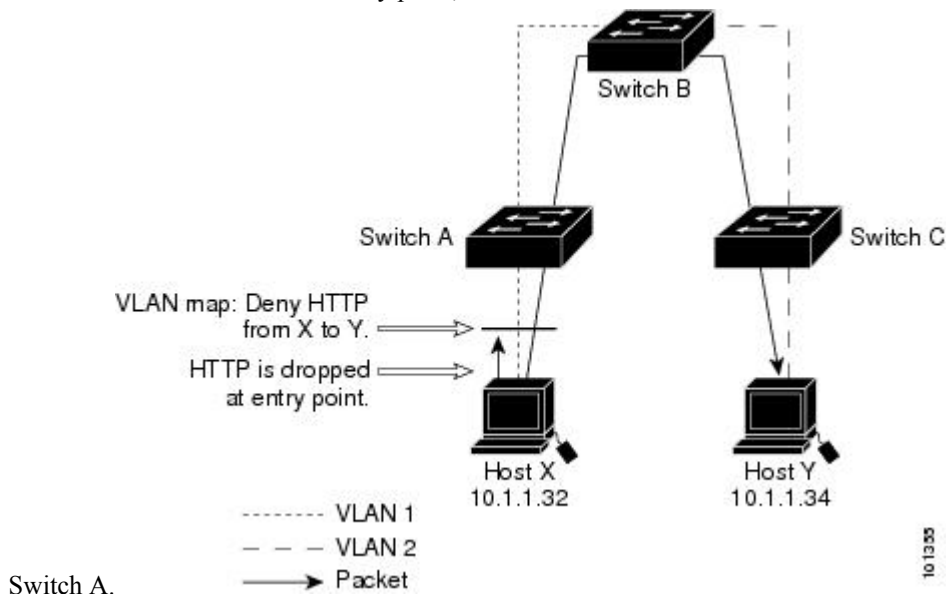
```

## Configuration Examples for Using VLAN Maps in Your Network

### Example: Wiring Closet Configuration

Figure 113: Wiring Closet Configuration

In a wiring closet configuration, routing might not be enabled on the switch. In this configuration, the switch can still support a VLAN map and a QoS classification ACL. Assume that Host X and Host Y are in different VLANs and are connected to wiring closet switches A and C. Traffic from Host X to Host Y is eventually being routed by Switch B, a Layer 3 switch with routing enabled. Traffic from Host X to Host Y can be access-controlled at the traffic entry point,



If you do not want HTTP traffic switched from Host X to Host Y, you can configure a VLAN map on Switch A to drop all HTTP traffic from Host X (IP address 10.1.1.32) to Host Y (IP address 10.1.1.34) at Switch A and not bridge it to Switch B.

First, define the IP access list *http* that permits (matches) any TCP traffic on the HTTP port.

```

Device(config)# ip access-list extended http
Device(config-ext-nacl)# permit tcp host 10.1.1.32 host 10.1.1.34 eq www
Device(config-ext-nacl)# exit

```

Next, create VLAN access map *map2* so that traffic that matches the *http* access list is dropped and all other IP traffic is forwarded.

```

Device(config)# vlan access-map map2 10
Device(config-access-map)# match ip address http

```

```

Device(config-access-map)# action drop
Device(config-access-map)# exit
Device(config)# ip access-list extended match_all
Device(config-ext-nacl)# permit ip any any
Device(config-ext-nacl)# exit
Device(config)# vlan access-map map2 20
Device(config-access-map)# match ip address match_all
Device(config-access-map)# action forward

```

Then, apply VLAN access map *map2* to VLAN 1.

```

Device(config)# vlan filter map2 vlan 1

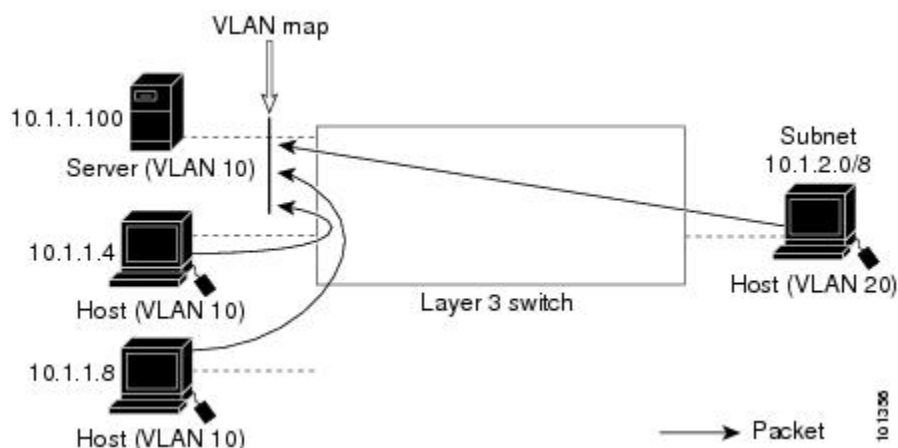
```

## Example: Restricting Access to a Server on Another VLAN

**Figure 114: Restricting Access to a Server on Another VLAN**

You can restrict access to a server on another VLAN. For example, server 10.1.1.100 in VLAN 10 needs to have access denied to these hosts:

- Hosts in subnet 10.1.2.0/8 in VLAN 20 should not have access.
- Hosts 10.1.1.4 and 10.1.1.8 in VLAN 10 should not have access.



## Example: Denying Access to a Server on Another VLAN

This example shows how to deny access to a server on another VLAN by creating the VLAN map SERVER1 that denies access to hosts in subnet 10.1.2.0.8, host 10.1.1.4, and host 10.1.1.8 and permits other IP traffic. The final step is to apply the map SERVER1 to VLAN 10.

Define the IP ACL that will match the correct packets.

```

Device(config)# ip access-list extended SERVER1_ACL
Device(config-ext-nacl)# permit ip 10.1.2.0 0.0.0.255 host 10.1.1.100
Device(config-ext-nacl)# permit ip host 10.1.1.4 host 10.1.1.100
Device(config-ext-nacl)# permit ip host 10.1.1.8 host 10.1.1.100
Device(config-ext-nacl)# exit

```

Define a VLAN map using this ACL that will drop IP packets that match SERVER1\_ACL and forward IP packets that do not match the ACL.

```
Device(config)# vlan access-map SERVER1_MAP
Device(config-access-map)# match ip address SERVER1_ACL
Device(config-access-map)# action drop
Device(config)# vlan access-map SERVER1_MAP 20
Device(config-access-map)# action forward
Device(config-access-map)# exit
```

Apply the VLAN map to VLAN 10.

```
Device(config)# vlan filter SERVER1_MAP vlan-list 10
```

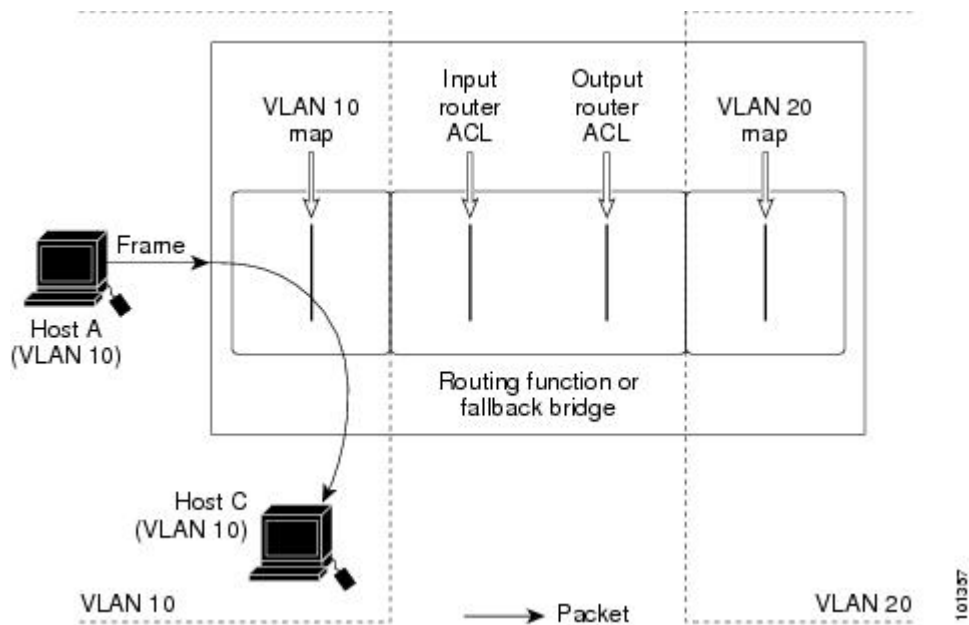
## Configuration Examples of Router ACLs and VLAN Maps Applied to VLANs

This section gives examples of applying router ACLs and VLAN maps to a VLAN for switched, bridged, routed, and multicast packets. Although the following illustrations show packets being forwarded to their destination, each time the packet's path crosses a line indicating a VLAN map or an ACL, it is also possible that the packet might be dropped, rather than forwarded.

### Example: ACLs and Switched Packets

*Figure 115: Applying ACLs on Switched Packets*

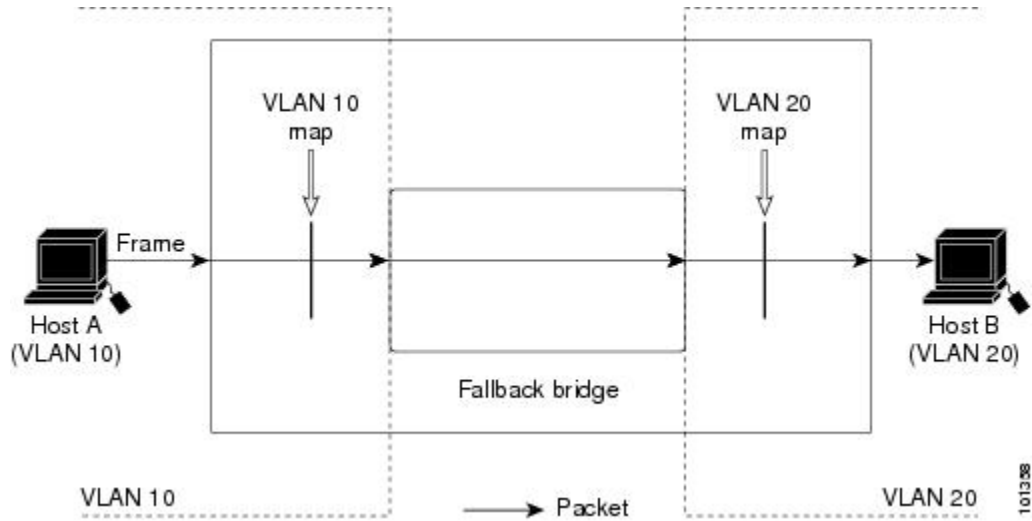
This example shows how an ACL is applied on packets that are switched within a VLAN. Packets switched within the VLAN without being routed or forwarded by fallback bridging are only subject to the VLAN map of the input VLAN.



## Example: ACLs and Bridged Packets

**Figure 116: Applying ACLs on Bridged Packets**

This example shows how an ACL is applied on fallback-bridged packets. For bridged packets, only Layer 2 ACLs are applied to the input VLAN. Only non-IP, non-ARP packets can be fallback-bridged.

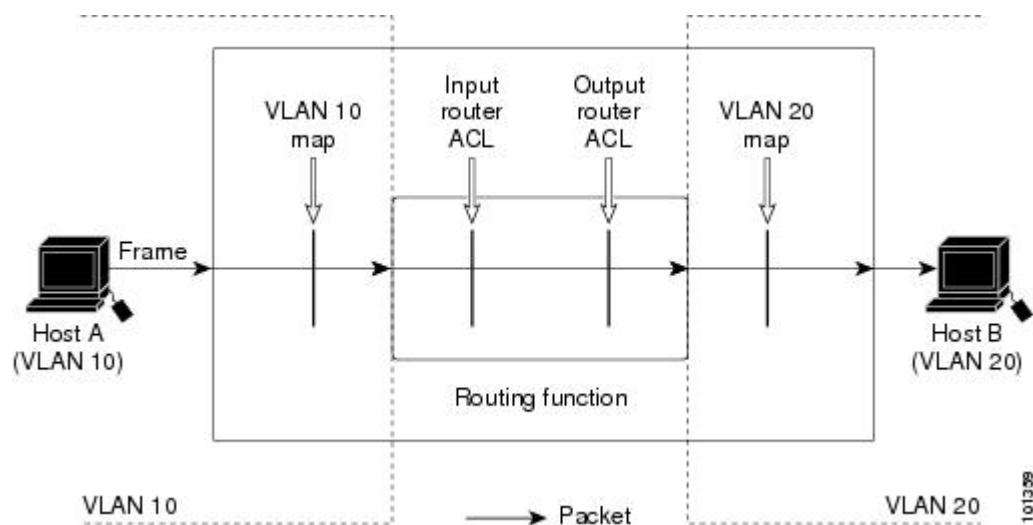


## Example: ACLs and Routed Packets

**Figure 117: Applying ACLs on Routed Packets**

This example shows how ACLs are applied on routed packets. The ACLs are applied in this order:

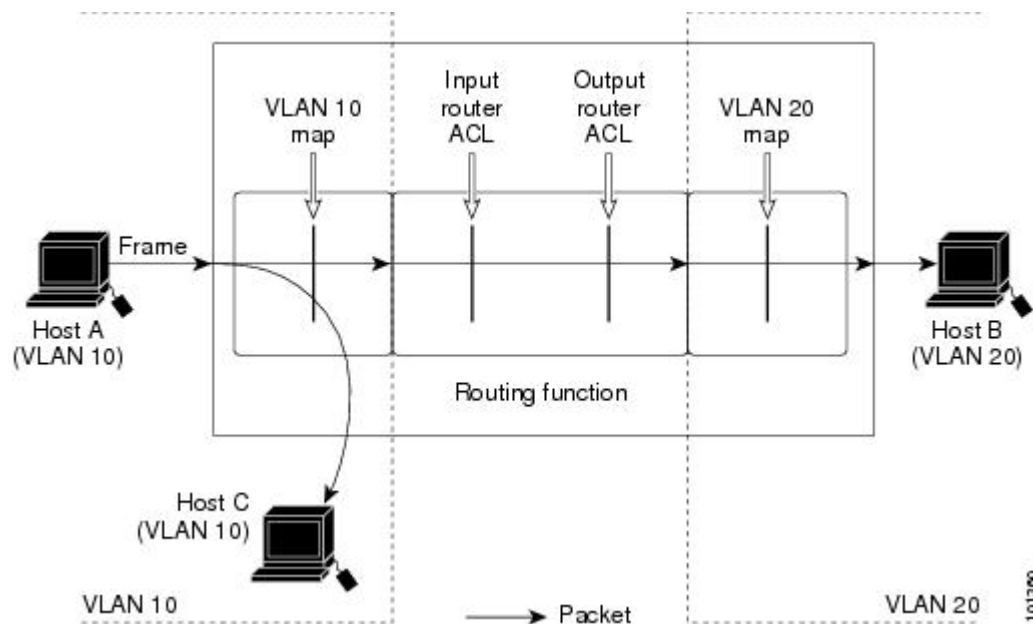
1. VLAN map for input VLAN
2. Input router ACL
3. Output router ACL
4. VLAN map for output VLAN



## Example: ACLs and Multicast Packets

Figure 118: Applying ACLs on Multicast Packets

This example shows how ACLs are applied on packets that are replicated for IP multicasting. A multicast packet being routed has two different kinds of filters applied: one for destinations that are other ports in the input VLAN and another for each of the destinations that are in other VLANs to which the packet has been routed. The packet might be routed to more than one output VLAN, in which case a different router output ACL and VLAN map would apply for each destination VLAN. The final result is that the packet might be permitted in some of the output VLANs and not in others. A copy of the packet is forwarded to those destinations where it is permitted. However, if the input VLAN map drops the packet, no destination receives a copy of the packet.



# Additional References

## Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Command List, All Releases</a>

## MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

## Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>







## CHAPTER 106

# IPv6 ACLs

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- [Finding Feature Information, on page 1923](#)
- [IPv6 ACLs Overview, on page 1923](#)
- [Restrictions for IPv6 ACLs, on page 1926](#)
- [Default Configuration for IPv6 ACLs , on page 1926](#)
- [Configuring IPv6 ACLs, on page 1927](#)
- [Attaching an IPv6 ACL to an Interface, on page 1930](#)
- [Configuring VLAN Maps, on page 1931](#)
- [Applying a VLAN Map to a VLAN, on page 1933](#)
- [Monitoring IPv6 ACLs, on page 1934](#)
- [Additional References, on page 1935](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## IPv6 ACLs Overview

You can filter IP Version 6 (IPv6) traffic by creating IPv6 access control lists (ACLs) and applying them to interfaces similar to how you create and apply IP Version 4 (IPv4) named ACLs. You can also create and apply input router ACLs to filter Layer 3 management traffic when the switch is running IP base and LAN base feature sets.

A switch supports three types of IPv6 ACLs:

- IPv6 router ACLs are supported on outbound or inbound traffic on Layer 3 interfaces, which can be routed ports, switch virtual interfaces (SVIs), or Layer 3 EtherChannels. IPv6 router ACLs apply only to IPv6 packets that are routed.

- IPv6 port ACLs are supported on outbound and inbound Layer 2 interfaces. IPv6 port ACLs are applied to all IPv6 packets entering the interface.
- VLAN ACLs or VLAN maps access-control all packets in a VLAN. You can use VLAN maps to filter traffic between devices in the same VLAN. ACL VLAN maps are applied on L2 VLANs. VLAN maps are configured to provide access control based on Layer 3 addresses for IPv6. Unsupported protocols are access-controlled through MAC addresses using Ethernet ACEs. After a VLAN map is applied to a VLAN, all packets entering the VLAN are checked against the VLAN map.

The switch supports VLAN ACLs (VLAN maps) for IPv6 traffic.

You can apply both IPv4 and IPv6 ACLs to an interface. As with IPv4 ACLs, IPv6 port ACLs take precedence over router ACLs.

## Switch Stacks and IPv6 ACLs

The active switch supports IPv6 ACLs in hardware and distributes the IPv6 ACLs to the stack members.

If a standby switch takes over as the active switch, it distributes the ACL configuration to all stack members. The member switches sync up the configuration distributed by the new active switch and flush out entries that are not required.

When an ACL is modified, attached to, or detached from an interface, the active switch distributes the change to all stack members.

## ACL Precedence

When VLAN maps, Port ACLs, and router ACLs are configured on the same switch, the filtering precedence, from greatest to least for ingress traffic is port ACL, VLAN map, and then router ACL. For egress traffic, the filtering precedence is router ACL, VLAN map, and then port ACL.

The following examples describe simple use cases:

- When both an input port ACL and a VLAN map are applied, incoming packets received on ports with a port ACL applied are filtered by the port ACL. Other packets are filtered by the VLAN map
- When an input router ACL and input port ACL exist in a switch virtual interface (SVI), incoming packets received on ports to which a port ACL is applied are filtered by the port ACL. Incoming routed IP packets received on other ports are filtered by the router ACL. Other packets are not filtered.
- When an output router ACL and input port ACL exist in an SVI, incoming packets received on the ports to which a port ACL is applied are filtered by the port ACL. Outgoing routed IP packets are filtered by the router ACL. Other packets are not filtered.
- When a VLAN map, input router ACL, and input port ACL exist in an SVI, incoming packets received on the ports to which a port ACL is applied are only filtered by the port ACL. Incoming routed IP packets received on other ports are filtered by both the VLAN map and the router ACL. Other packets are filtered only by the VLAN map.
- When a VLAN map, output router ACL, and input port ACL exist in an SVI, incoming packets received on the ports to which a port ACL is applied are only filtered by the port ACL. Outgoing routed IP packets are filtered by both the VLAN map and the router ACL. Other packets are filtered only by the VLAN map.

### Related Topics

[Restrictions for Configuring IPv4 Access Control Lists](#), on page 1886

## VLAN Maps

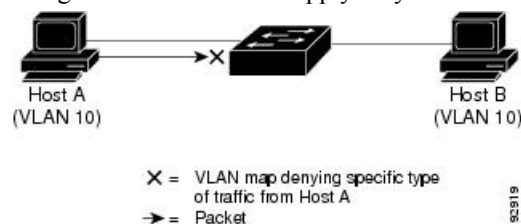
VLAN ACLs or VLAN maps are used to control network traffic within a VLAN. You can apply VLAN maps to all packets that are bridged within a VLAN in the switch or switch stack. VACLs are strictly for security packet filtering and for redirecting traffic to specific physical interfaces. VACLs are not defined by direction (ingress or egress).

All non-IP protocols are access-controlled through MAC addresses and Ethertype using MAC VLAN maps. (IP traffic is not access controlled by MAC VLAN maps.) You can enforce VLAN maps only on packets going through the switch; you cannot enforce VLAN maps on traffic between hosts on a hub or on another switch connected to this switch.

With VLAN maps, forwarding of packets is permitted or denied, based on the action specified in the map.

**Figure 119: Using VLAN Maps to Control Traffic**

This shows how a VLAN map is applied to prevent a specific type of traffic from Host A in VLAN 10 from being forwarded. You can apply only one VLAN map to a VLAN.



## Interactions with Other Features and Switches

- If an IPv6 router ACL is configured to deny a packet, the packet is not routed. A copy of the packet is sent to the Internet Control Message Protocol (ICMP) queue to generate an ICMP unreachable message for the frame.
- If a bridged frame is to be dropped due to a port ACL, the frame is not bridged.
- You can create both IPv4 and IPv6 ACLs on a switch or switch stack, and you can apply both IPv4 and IPv6 ACLs to the same interface. Each ACL must have a unique name; an error message appears if you try to use a name that is already configured.

You use different commands to create IPv4 and IPv6 ACLs and to attach IPv4 or IPv6 ACLs to the same Layer 2 or Layer 3 interface. If you use the wrong command to attach an ACL (for example, an IPv4 command to attach an IPv6 ACL), you receive an error message.

- You cannot use MAC ACLs to filter IPv6 frames. MAC ACLs can only filter non-IP frames.
- If the hardware memory is full, packets are dropped on the interface and an unload error message is logged.

## Restrictions for IPv6 ACLs

With IPv4, you can configure standard and extended numbered IP ACLs, named IP ACLs, and MAC ACLs. IPv6 supports only named ACLs.

The switch supports most Cisco IOS-supported IPv6 ACLs with some exceptions:

- The switch does not support matching on these keywords: **routing header**, and **undetermined-transport**.
- The switch does not support reflexive ACLs (the **reflect** keyword).
- This release supports port ACLs, router ACLs and VLAN ACLs (VLAN maps) for IPv6.
- The switch does not apply MAC-based ACLs on IPv6 frames.
- When configuring an ACL, there is no restriction on keywords entered in the ACL, regardless of whether or not they are supported on the platform. When you apply the ACL to an interface that requires hardware forwarding (physical ports or SVIs), the switch checks to determine whether or not the ACL can be supported on the interface. If not, attaching the ACL is rejected.
- If an ACL is applied to an interface and you attempt to add an access control entry (ACE) with an unsupported keyword, the switch does not allow the ACE to be added to the ACL that is currently attached to the interface.

IPv6 ACLs on the switch have these characteristics:

- Fragmented frames (the **fragments** keyword as in IPv4) are supported
- The same statistics supported in IPv4 are supported for IPv6 ACLs.
- If the switch runs out of hardware space, the packets associated with the ACL are dropped on the interface.
- Logging is supported for router ACLs, but not for port ACLs.
- The switch supports IPv6 address-matching for a full range of prefix-lengths.

## Default Configuration for IPv6 ACLs

The default IPv6 ACL configuration is as follows:

```
Switch# show access-lists preauth_ipv6_acl
IPv6 access list preauth_ipv6_acl (per-user)
permit udp any any eq domain sequence 10
permit tcp any any eq domain sequence 20
permit icmp any any nd-ns sequence 30
permit icmp any any nd-na sequence 40
permit icmp any any router-solicitation sequence 50
permit icmp any any router-advertisement sequence 60
permit icmp any any redirect sequence 70
permit udp any eq 547 any eq 546 sequence 80
permit udp any eq 546 any eq 547 sequence 90
deny ipv6 any any sequence 100
```

# Configuring IPv6 ACLs

To filter IPv6 traffic, you perform these steps:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>[no]{ipv6 access-list list-name  client permit-control-packets  log-update threshold  role-based list-name}</b> <b>Example:</b> Device (config)# <b>ipv6 access-list example_acl_list</b>	Defines an IPv6 ACL name, and enters IPv6 access list configuration mode.
<b>Step 4</b>	<b>[no]{deny   permit} protocol {source-ipv6-prefix/prefix-length any threshold  host source-ipv6-address} [ operator [ port-number ] ] { destination-ipv6-prefix/ prefix-length   any   host destination-ipv6-address} [operator [port-number]][dscp value] [fragments] [log] [log-input] [routing] [sequence value] [time-range name]</b>	Enter deny or permit to specify whether to deny or permit the packet if conditions are matched. These are the conditions: <ul style="list-style-type: none"> <li>• For protocol, enter the name or number of an Internet protocol: <b>ahp</b>, <b>esp</b>, <b>icmp</b>, <b>ipv6</b>, <b>pcp</b>, <b>stcp</b>, <b>tcp</b>, or <b>udp</b>, or an integer in the range 0 to 255 representing an IPv6 protocol number.</li> <li>• The <i>source-ipv6-prefix/prefix-length</i> or <i>destination-ipv6-prefix/ prefix-length</i> is the source or destination IPv6 network or class of networks for which to set deny or permit conditions, specified in hexadecimal and using 16-bit values between colons (see RFC 2373).</li> <li>• Enter any as an abbreviation for the IPv6 prefix ::/0.</li> <li>• For <b>host source-ipv6-address</b> or <i>destination-ipv6-address</i>, enter the source or destination IPv6 host address for which</li> </ul>

	Command or Action	Purpose
		<p>to set deny or permit conditions, specified in hexadecimal using 16-bit values between colons.</p> <ul style="list-style-type: none"> <li>• (Optional) For operator, specify an operand that compares the source or destination ports of the specified protocol. Operands are <b>lt</b> (less than), <b>gt</b> (greater than), <b>eq</b> (equal), <b>neq</b> (not equal), and <b>range</b>.</li> </ul> <p>If the operator follows the <i>source-ipv6-prefix/prefix-length</i> argument, it must match the source port. If the operator follows the <i>destination-ipv6-prefix/prefix-length</i> argument, it must match the destination port.</p> <ul style="list-style-type: none"> <li>• (Optional) The <b>port-number</b> is a decimal number from 0 to 65535 or the name of a TCP or UDP port. You can use TCP port names only when filtering TCP. You can use UDP port names only when filtering UDP.</li> <li>• (Optional) Enter <b>dscp</b> value to match a differentiated services code point value against the traffic class value in the Traffic Class field of each IPv6 packet header. The acceptable range is from 0 to 63.</li> <li>• (Optional) Enter <b>fragments</b> to check noninitial fragments. This keyword is visible only if the protocol is ipv6.</li> <li>• (Optional) Enter <b>log</b> to cause an logging message to be sent to the console about the packet that matches the entry. Enter <b>log-input</b> to include the input interface in the log entry. Logging is supported only for router ACLs.</li> <li>• (Optional) Enter <b>routing</b> to specify that IPv6 packets be routed.</li> <li>• (Optional) Enter <b>sequence value</b> to specify the sequence number for the access list statement. The acceptable range is from 1 to 4,294,967,295.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>(Optional) Enter <b>time-range</b> name to specify the time range that applies to the deny or permit statement.</li> </ul>
<b>Step 5</b>	<pre>{deny   permit} tcp {source-ipv6-prefix/prefix-length   any   host source-ipv6-address} [operator [port-number]] {destination-ipv6- prefix/prefix-length   any   host destination-ipv6-address} [operator [port-number]] [ack] [dscp value] [established] [fin] [log] [log-input] [neq {port   protocol}] [psh] [range {port   protocol}] [rst] [routing] [sequence value] [syn] [time-range name] [urg]</pre>	<p>(Optional) Define a TCP access list and the access conditions.</p> <p>Enter <b>tcp</b> for Transmission Control Protocol. The parameters are the same as those described in Step 3a, with these additional optional parameters:</p> <ul style="list-style-type: none"> <li><b>ack</b>—Acknowledgment bit set.</li> <li><b>established</b>—An established connection. A match occurs if the TCP datagram has the ACK or RST bits set.</li> <li><b>fin</b>—Finished bit set; no more data from sender.</li> <li><b>neq</b> {port   protocol}—Matches only packets that are not on a given port number.</li> <li><b>psh</b>—Push function bit set.</li> <li><b>range</b> {port   protocol}—Matches only packets in the port number range.</li> <li><b>rst</b>—Reset bit set.</li> <li><b>syn</b>—Synchronize bit set.</li> <li><b>urg</b>—Urgent pointer bit set.</li> </ul>
<b>Step 6</b>	<pre>{deny   permit} udp {source-ipv6-prefix/prefix-length   any   host source-ipv6-address} [operator [port-number]] {destination-ipv6-prefix/prefix-length   any   host destination-ipv6-address} [operator [port-number]] [dscp value] [log] [log-input] [neq {port   protocol}] [range {port   protocol}] [routing] [sequence value] [time-range name]]</pre>	<p>(Optional) Define a UDP access list and the access conditions.</p> <p>Enter <b>udp</b> for the User Datagram Protocol. The UDP parameters are the same as those described for TCP, except that the [operator [port]] port number or name must be a UDP port number or name, and the established parameter is not valid for UDP.</p>
<b>Step 7</b>	<pre>{deny   permit} icmp {source-ipv6-prefix/prefix-length   any   host source-ipv6-address} [operator [port-number]] {destination-ipv6-prefix/prefix-length   any   host destination-ipv6-address} [operator [port-number]] [icmp-type [icmp-code]]  </pre>	<p>(Optional) Define an ICMP access list and the access conditions.</p> <p>Enter <b>icmp</b> for Internet Control Message Protocol. The ICMP parameters are the same as those described for most IP protocols in Step 1, with the addition of the ICMP message type</p>

	Command or Action	Purpose
	<code>icmp-message</code> [ <code>dscp value</code> ] [ <code>log</code> ] [ <code>log-input</code> ] [ <code>routing</code> ] [ <code>sequence value</code> ] [ <code>time-range name</code> ]	and code parameters. These optional keywords have these meanings: <ul style="list-style-type: none"> <li>• <i>icmp-type</i>—Enter to filter by ICMP message type, a number from 0 to 255.</li> <li>• <i>icmp-code</i>—Enter to filter ICMP packets that are filtered by the ICMP message code type, a number from 0 to 255.</li> <li>• <i>icmp-message</i>—Enter to filter ICMP packets by the ICMP message type name or the ICMP message type and code name. To see a list of ICMP message type names and code names, use the ? key or see command reference for this release.</li> </ul>
<b>Step 8</b>	<code>end</code>	Return to privileged EXEC mode.
<b>Step 9</b>	<code>show ipv6 access-list</code>	Verify the access list configuration.
<b>Step 10</b>	<code>show running-config</code> <b>Example:</b>  Device# <code>show running-config</code>	Verifies your entries.
<b>Step 11</b>	<code>copy running-config startup-config</code> <b>Example:</b>  Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

**What to do next**

Attach the IPv6 ACL to an Interface

## Attaching an IPv6 ACL to an Interface

You can apply an ACL to outbound or inbound traffic on Layer 3 interfaces, or to inbound traffic on Layer 2 interfaces. You can also apply ACLs only to inbound management traffic on Layer 3 interfaces.

Follow these steps to control access to an interface:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<code>enable</code>	Enables privileged EXEC mode.



	Command or Action	Purpose
	<b>Example:</b>  Device> <b>enable</b>	<ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>interface-id</i>	Identify a Layer 2 interface (for port ACLs) or Layer 3 interface (for router ACLs) on which to apply an access list, and enter interface configuration mode.
<b>Step 4</b>	<b>no switchport</b>	If applying a router ACL, this changes the interface from Layer 2 mode (the default) to Layer 3 mode.
<b>Step 5</b>	<b>ipv6 address</b> <i>ipv6-address</i>	Configure an IPv6 address on a Layer 3 interface (for router ACLs).
<b>Step 6</b>	<b>ipv6 traffic-filter</b> <i>access-list-name</i> { <b>in</b>   <b>out</b> }	Apply the access list to incoming or outgoing traffic on the interface.
<b>Step 7</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show running-config</b>  <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 9</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring VLAN Maps

To create a VLAN map and apply it to one or more VLANs, perform these steps:

**Before you begin**

Create the IPv6 ACL that you want to apply to the VLAN.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>vlan access-map</b> <i>name</i> [ <i>number</i> ] <b>Example:</b> Device(config)# <b>vlan access-map map_1 20</b>	Creates a VLAN map, and give it a name and (optionally) a number. The number is the sequence number of the entry within the map. When you create VLAN maps with the same name, numbers are assigned sequentially in increments of 10. When modifying or deleting maps, you can enter the number of the map entry that you want to modify or delete. VLAN maps do not use the specific permit or deny keywords. To deny a packet by using VLAN maps, create an ACL that would match the packet, and set the action to drop. A permit in the ACL counts as a match. A deny in the ACL means no match. Entering this command changes to access-map configuration mode.
<b>Step 4</b>	<b>match</b> { <b>ip</b>   <b>ipv6</b>   <b>mac</b> } <b>address</b> { <i>name</i>   <i>number</i> } [ <i>name</i>   <i>number</i> ] <b>Example:</b> Device(config-access-map)# <b>match ipv6 address ip_net</b>	Match the packet against one or more access lists. Note that packets are only matched against access lists of the correct protocol type. IP packets are matched against IP access lists. Non-IP packets are only matched against named MAC access lists.

	Command or Action	Purpose
		<p><b>Note</b> If the VLAN map is configured with a match clause for a type of packet (IP or MAC) and the map action is drop, all packets that match the type are dropped. If the VLAN map has no match clause, and the configured action is drop, all IP and Layer 2 packets are dropped.</p>
<b>Step 5</b>	<p>Enter one of the following commands to specify an IP packet or a non-IP packet (with only a known MAC address) and to match the packet against one or more ACLs:</p> <ul style="list-style-type: none"> <li>• <b>action { forward }</b></li> </ul> <pre>Device(config-access-map)# action forward</pre> <ul style="list-style-type: none"> <li>• <b>action { drop }</b></li> </ul> <pre>Device(config-access-map)# action drop</pre>	Sets the action for the map entry.
<b>Step 6</b>	<p><b>vlan filter mapname vlan-list list</b></p> <p><b>Example:</b></p> <pre>Device(config)# vlan filter map 1 vlan-list 20-22</pre>	<p>Applies the VLAN map to one or more VLAN IDs.</p> <p>The list can be a single VLAN ID (22), a consecutive list (10-22), or a string of VLAN IDs (12, 22, 30). Spaces around the comma and hyphen are optional.</p>

## Applying a VLAN Map to a VLAN

Beginning in privileged EXEC mode, follow the procedure given below to apply a VLAN map to one or more VLANs:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>		
<b>Step 2</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<p><b>vlan filter mapname vlan-list list</b></p> <p><b>Example:</b></p>	Applies the VLAN map to one or more VLAN IDs.

	Command or Action	Purpose
	Device(config)# <b>vlan filter map 1 vlan-list 20-22</b>	The list can be a single VLAN ID (22), a consecutive list (10-22), or a string of VLAN IDs (12, 22, 30). Spaces around the comma and hyphen are optional.
<b>Step 4</b>	<b>end</b>  <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b>  <b>Example:</b>  Device# <b>show running-config</b>	Displays the access list configuration.
<b>Step 6</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Configuring VLAN Maps](#), on page 1902

## Monitoring IPv6 ACLs

You can display information about all configured access lists, all IPv6 access lists, or a specific access list by using one or more of the privileged EXEC commands shown in the table below:

Command	Purpose
<b>show access-lists</b>	Displays all access lists configured on the switch.
<b>show ipv6 access-list</b> [ <i>access-list-name</i> ]	Displays all configured IPv6 access lists or the access list specified by name.
<b>show vlan access-map</b> [ <i>map-name</i> ]	Displays VLAN access map configuration.
<b>show vlan filter</b> [ <b>access-map</b> <i>access-map</i>   <b>vlan</b> <i>vlan-id</i> ]	Displays the mapping between VACLs and VLANs.

This is an example of the output from the show access-lists privileged EXEC command. The output shows all access lists that are configured on the switch or switch stack.

```
Switch # show access-lists
Extended IP access list hello
  10 permit ip any any
```

```
IPv6 access list ipv6
  permit ipv6 any any sequence 10
```

This is an example of the output from the **show ipv6 access-list** privileged EXEC command. The output shows only IPv6 access lists configured on the switch or switch stack

```
Switch# show ipv6 access-list
IPv6 access list inbound
  permit tcp any any eq bgp (8 matches) sequence 10
  permit tcp any any eq telnet (15 matches) sequence 20
  permit udp any any sequence 30
IPv6 access list outbound
  deny udp any any sequence 10
  deny tcp any any eq telnet sequence 20
```

This is an example of the output from the **show vlan access-map** privileged EXEC command. The output shows VLAN access map information.

```
Switch# show vlan access-map
Vlan access-map "m1" 10
  Match clauses:
    ipv6 address: ip2
  Action: drop
```

## Additional References

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<i><a href="#">Cisco IOS Master Command List, All Releases</a></i>

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>



## CHAPTER 107

# Configuring DHCP

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- [Finding Feature Information, on page 1937](#)
- [Information About DHCP, on page 1937](#)
- [How to Configure DHCP Features, on page 1944](#)
- [Configuring DHCP Server Port-Based Address Allocation, on page 1950](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About DHCP

### DHCP Server

The DHCP server assigns IP addresses from specified address pools on a switch or router to DHCP clients and manages them. If the DHCP server cannot give the DHCP client the requested configuration parameters from its database, it forwards the request to one or more secondary DHCP servers defined by the network administrator. The switch can act as a DHCP server.

### DHCP Relay Agent

A DHCP relay agent is a Layer 3 device that forwards DHCP packets between clients and servers. Relay agents forward requests and replies between clients and servers when they are not on the same physical subnet. Relay agent forwarding is different from the normal Layer 2 forwarding, in which IP datagrams are switched transparently between networks. Relay agents receive DHCP messages and generate new DHCP messages to send on output interfaces.

## DHCP Snooping

DHCP snooping is a DHCP security feature that provides network security by filtering untrusted DHCP messages and by building and maintaining a DHCP snooping binding database, also referred to as a DHCP snooping binding table.

DHCP snooping acts like a firewall between untrusted hosts and DHCP servers. You use DHCP snooping to differentiate between untrusted interfaces connected to the end user and trusted interfaces connected to the DHCP server or another switch.



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**Note** For DHCP snooping to function properly, all DHCP servers must be connected to the switch through trusted interfaces.

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An untrusted DHCP message is a message that is received through an untrusted interface. By default, the switch considers all interfaces untrusted. So, the switch must be configured to trust some interfaces to use DHCP Snooping. When you use DHCP snooping in a service-provider environment, an untrusted message is sent from a device that is not in the service-provider network, such as a customer's switch. Messages from unknown devices are untrusted because they can be sources of traffic attacks.

The DHCP snooping binding database has the MAC address, the IP address, the lease time, the binding type, the VLAN number, and the interface information that corresponds to the local untrusted interfaces of a switch. It does not have information regarding hosts interconnected with a trusted interface.

In a service-provider network, an example of an interface you might configure as trusted is one connected to a port on a device in the same network. An example of an untrusted interface is one that is connected to an untrusted interface in the network or to an interface on a device that is not in the network.

When a switch receives a packet on an untrusted interface and the interface belongs to a VLAN in which DHCP snooping is enabled, the switch compares the source MAC address and the DHCP client hardware address. If the addresses match (the default), the switch forwards the packet. If the addresses do not match, the switch drops the packet.

The switch drops a DHCP packet when one of these situations occurs:

- A packet from a DHCP server, such as a DHCP OFFER, DHCP ACK, DHCP NAK, or DHCP REQUEST packet, is received from outside the network or firewall.
- A packet is received on an untrusted interface, and the source MAC address and the DHCP client hardware address do not match.
- The switch receives a DHCP RELEASE or DHCP DECLINE broadcast message that has a MAC address in the DHCP snooping binding database, but the interface information in the binding database does not match the interface on which the message was received.
- A DHCP relay agent forwards a DHCP packet that includes a relay-agent IP address that is not 0.0.0.0, or the relay agent forwards a packet that includes option-82 information to an untrusted port.
- The maximum snooping queue size of 1000 is exceeded when DHCP snooping is enabled.



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**Note** This is applicable from Cisco IOS XE Denali 16.1.x release onwards.

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If the switch is an aggregation switch supporting DHCP snooping and is connected to an edge switch that is inserting DHCP option-82 information, the switch drops packets with option-82 information when packets are received on an untrusted interface. If DHCP snooping is enabled and packets are received on a trusted port, the aggregation switch does not learn the DHCP snooping bindings for connected devices and cannot build a complete DHCP snooping binding database.

When an aggregation switch can be connected to an edge switch through an untrusted interface and you enter the **ip dhcp snooping information option allow-untrusted** global configuration command, the aggregation switch accepts packets with option-82 information from the edge switch. The aggregation switch learns the bindings for hosts connected through an untrusted switch interface. The DHCP security features, such as dynamic ARP inspection or IP source guard, can still be enabled on the aggregation switch while the switch receives packets with option-82 information on untrusted input interfaces to which hosts are connected. The port on the edge switch that connects to the aggregation switch must be configured as a trusted interface.

Normally, it is not desirable to broadcast packets to wireless clients. So, DHCP snooping replaces destination broadcast MAC address (ffff.ffff.ffff) with unicast MAC address for DHCP packets that are going from server to wireless clients. The unicast MAC address is retrieved from CHADDR field in the DHCP payload. This processing is applied for server to client packets such as DHCP OFFER, DHCP ACK, and DHCP NACK messages. The **ip dhcp snooping wireless bootp-broadcast enable** can be used to revert this behavior. When the wireless BOOTP broadcast is enabled, the broadcast DHCP packets from server are forwarded to wireless clients without changing the destination MAC address.

#### Related Topics

[Prerequisites for Configuring DHCP Snooping and Option 82](#), on page 1948

## Option-82 Data Insertion

In residential, metropolitan Ethernet-access environments, DHCP can centrally manage the IP address assignments for a large number of subscribers. When the DHCP option-82 feature is enabled on the switch, a subscriber device is identified by the switch port through which it connects to the network (in addition to its MAC address). Multiple hosts on the subscriber LAN can be connected to the same port on the access switch and are uniquely identified.



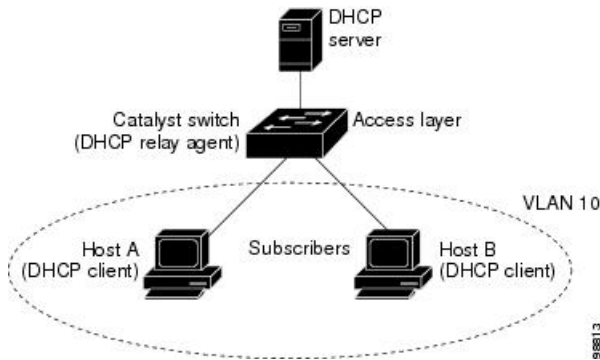
---

**Note** The DHCP option-82 feature is supported only when DHCP snooping is globally enabled on the VLANs to which subscriber devices using option-82 are assigned.

---

The following illustration shows a metropolitan Ethernet network in which a centralized DHCP server assigns IP addresses to subscribers connected to the switch at the access layer. Because the DHCP clients and their associated DHCP server do not reside on the same IP network or subnet, a DHCP relay agent (the Catalyst switch) is configured with a helper address to enable broadcast forwarding and to transfer DHCP messages between the clients and the server.

Figure 120: DHCP Relay Agent in a Metropolitan Ethernet Network



When you enable the DHCP snooping information option 82 on the switch, the following sequence of events occurs:

- The host (DHCP client) generates a DHCP request and broadcasts it on the network.
- When the switch receives the DHCP request, it adds the option-82 information in the packet. By default, the remote-ID suboption is the switch MAC address, and the circuit-ID suboption is the port identifier, **vlan-mod-port**, from which the packet is received. You can configure the remote ID and circuit ID.
- If the IP address of the relay agent is configured, the switch adds this IP address in the DHCP packet.
- The switch forwards the DHCP request that includes the option-82 field to the DHCP server.
- The DHCP server receives the packet. If the server is option-82-capable, it can use the remote ID, the circuit ID, or both to assign IP addresses and implement policies, such as restricting the number of IP addresses that can be assigned to a single remote ID or circuit ID. Then the DHCP server echoes the option-82 field in the DHCP reply.
- The DHCP server unicasts the reply to the switch if the request was relayed to the server by the switch. The switch verifies that it originally inserted the option-82 data by inspecting the remote ID and possibly the circuit ID fields. The switch removes the option-82 field and forwards the packet to the switch port that connects to the DHCP client that sent the DHCP request.

In the default suboption configuration, when the described sequence of events occurs, the values in these fields do not change (see the illustration, *Suboption Packet Formats*):

- Circuit-ID suboption fields
  - Suboption type
  - Length of the suboption type
  - Circuit-ID type
  - Length of the circuit-ID type
- Remote-ID suboption fields
  - Suboption type
  - Length of the suboption type
  - Remote-ID type

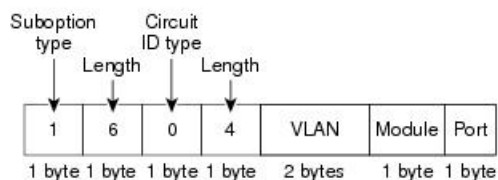
- Length of the remote-ID type

In the port field of the circuit ID suboption, the port numbers start at 3. For example, on a switch with 24 10/100/1000 ports and four small form-factor pluggable (SFP) module slots, port 3 is the Gigabit Ethernet 1/0/1 port, port 4 is the Gigabit Ethernet 1/0/2 port, and so forth. Port 27 is the SFP module slot Gigabit Ethernet1/0/25, and so forth.

The illustration, *Suboption Packet Formats*, shows the packet formats for the remote-ID suboption and the circuit-ID suboption when the default suboption configuration is used. For the circuit-ID suboption, the module number corresponds to the switch number in the stack. The switch uses the packet formats when you globally enable DHCP snooping and enter the `ip dhcp snooping information option global` configuration command.

**Figure 121: Suboption Packet Formats**

#### Circuit ID Suboption Frame Format



#### Remote ID Suboption Frame Format

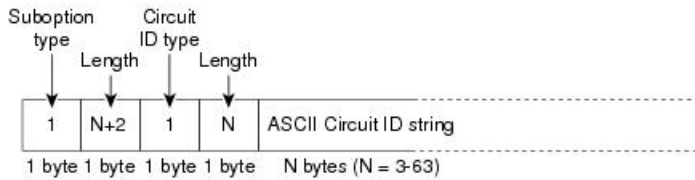
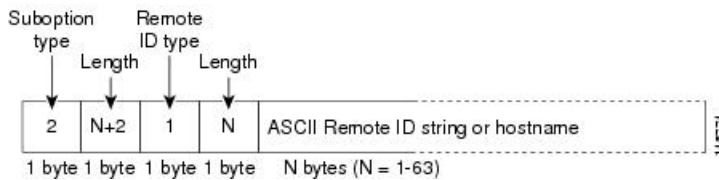


The illustration, *User-Configured Suboption Packet Formats*, shows the packet formats for user-configured remote-ID and circuit-ID suboptions. The switch uses these packet formats when DHCP snooping is globally enabled and when the `ip dhcp snooping information option format remote-id` global configuration command and the `ip dhcp snooping vlan information option format-type circuit-id string` interface configuration command are entered.

The values for these fields in the packets change from the default values when you configure the remote-ID and circuit-ID suboptions:

- Circuit-ID suboption fields
  - The circuit-ID type is 1.
  - The length values are variable, depending on the length of the string that you configure.
- Remote-ID suboption fields
  - The remote-ID type is 1.
  - The length values are variable, depending on the length of the string that you configure.

Figure 122: User-Configured Suboption Packet Formats

**Circuit ID Suboption Frame Format (for user-configured string):****Remote ID Suboption Frame Format (for user-configured string):**

## Cisco IOS DHCP Server Database

During the DHCP-based autoconfiguration process, the designated DHCP server uses the Cisco IOS DHCP server database. It has IP addresses, address bindings, and configuration parameters, such as the boot file.

An address binding is a mapping between an IP address and a MAC address of a host in the Cisco IOS DHCP server database. You can manually assign the client IP address, or the DHCP server can allocate an IP address from a DHCP address pool. For more information about manual and automatic address bindings, see the “Configuring DHCP” chapter of the *Cisco IOS IP Configuration Guide, Release 12.4*.

For procedures to enable and configure the Cisco IOS DHCP server database, see the “DHCP Configuration Task List” section in the “Configuring DHCP” chapter of the *Cisco IOS IP Configuration Guide, Release 12.4*.

## DHCP Snooping Binding Database

When DHCP snooping is enabled, the switch uses the DHCP snooping binding database to store information about untrusted interfaces. The database can have up to 64,000 bindings.

Each database entry (binding) has an IP address, an associated MAC address, the lease time (in hexadecimal format), the interface to which the binding applies, and the VLAN to which the interface belongs. The database agent stores the bindings in a file at a configured location. At the end of each entry is a checksum that accounts for all the bytes from the start of the file through all the bytes associated with the entry. Each entry is 72 bytes, followed by a space and then the checksum value.

To keep the bindings when the switch reloads, you must use the DHCP snooping database agent. If the agent is disabled, dynamic ARP inspection or IP source guard is enabled, and the DHCP snooping binding database has dynamic bindings, the switch loses its connectivity. If the agent is disabled and only DHCP snooping is enabled, the switch does not lose its connectivity, but DHCP snooping might not prevent DHCP spoofing attacks.

When reloading, the switch reads the binding file to build the DHCP snooping binding database. The switch updates the file when the database changes.

When a switch learns of new bindings or when it loses bindings, the switch immediately updates the entries in the database. The switch also updates the entries in the binding file. The frequency at which the file is

updated is based on a configurable delay, and the updates are batched. If the file is not updated in a specified time (set by the write-delay and abort-timeout values), the update stops.

This is the format of the file with bindings:

```
<initial-checksum>
TYPE DHCP-SNOOPING
VERSION 1
BEGIN
<entry-1> <checksum-1>
<entry-2> <checksum-1-2>
...
...
<entry-n> <checksum-1-2-...-n>
END
```

Each entry in the file is tagged with a checksum value that the switch uses to verify the entries when it reads the file. The initial-checksum entry on the first line distinguishes entries associated with the latest file update from entries associated with a previous file update.

This is an example of a binding file:

```
2bb4c2a1
TYPE DHCP-SNOOPING
VERSION 1
BEGIN
192.1.168.1 3 0003.47d8.c91f 2BB6488E Gi1/0/4 21ae5fbb
192.1.168.3 3 0003.44d6.c52f 2BB648EB Gi1/0/4 1bdb223f
192.1.168.2 3 0003.47d9.c8f1 2BB648AB Gi1/0/4 584a38f0
END
```

When the switch starts and the calculated checksum value equals the stored checksum value, the switch reads entries from the binding file and adds the bindings to its DHCP snooping binding database. The switch ignores an entry when one of these situations occurs:

- The switch reads the entry and the calculated checksum value does not equal the stored checksum value. The entry and the ones following it are ignored.
- An entry has an expired lease time (the switch might not remove a binding entry when the lease time expires).
- The interface in the entry no longer exists on the system.
- The interface is a routed interface or a DHCP snooping-trusted interface.

## DHCP Snooping and Switch Stacks

DHCP snooping is managed on the stack master. When a new switch joins the stack, the switch receives the DHCP snooping configuration from the stack master. When a member leaves the stack, all DHCP snooping address bindings associated with the switch age out.

All snooping statistics are generated on the stack master. If a new stack master is elected, the statistics counters reset.

When a stack merge occurs, all DHCP snooping bindings in the stack master are lost if it is no longer the stack master. With a stack partition, the existing stack master is unchanged, and the bindings belonging to the

partitioned switches age out. The new master of the partitioned stack begins processing the new incoming DHCP packets.

# How to Configure DHCP Features

## Default DHCP Snooping Configuration

Table 145: Default DHCP Configuration

Feature	Default Setting
DHCP server	Enabled in Cisco IOS software, requires configuration <sup>13</sup>
DHCP relay agent	Enabled <sup>14</sup>
DHCP packet forwarding address	None configured
Checking the relay agent information	Enabled (invalid messages are dropped)
DHCP relay agent forwarding policy	Replace the existing relay agent information
DHCP snooping enabled globally	Disabled
DHCP snooping information option	Enabled
DHCP snooping option to accept packets on untrusted input interfaces <sup>15</sup>	Disabled
DHCP snooping limit rate	None configured
DHCP snooping trust	Untrusted
DHCP snooping VLAN	Disabled
DHCP snooping MAC address verification	Enabled
Cisco IOS DHCP server binding database	Enabled in Cisco IOS software, requires configuration. <b>Note</b> The switch gets network addresses and configuration parameters only from a device configured as a DHCP server.
DHCP snooping binding database agent	Enabled in Cisco IOS software, requires configuration. This feature is operational only when a destination is configured.

<sup>13</sup> The switch responds to DHCP requests only if it is configured as a DHCP server.

<sup>14</sup> The switch relays DHCP packets only if the IP address of the DHCP server is configured on the SVI of the DHCP client.

- <sup>15</sup> Use this feature when the switch is an aggregation switch that receives packets with option-82 information from an edge switch.

## DHCP Snooping Configuration Guidelines

- If a switch port is connected to a DHCP server, configure a port as trusted by entering the **ip dhcp snooping trust interface** configuration command.
- If a switch port is connected to a DHCP client, configure a port as untrusted by entering the **no ip dhcp snooping trust** interface configuration command.
- You can display DHCP snooping statistics by entering the **show ip dhcp snooping statistics** user EXEC command, and you can clear the snooping statistics counters by entering the **clear ip dhcp snooping statistics** privileged EXEC command.

## Configuring the DHCP Server

The switch can act as a DHCP server. If IOS based DHCP server for DHCP clients with management ports are used, both DHCP pool and the corresponding interface must be configured using the Management VRF.

For procedures to configure the switch as a DHCP server, see the “Configuring DHCP” section of the “IP addressing and Services” section of the *Cisco IOS IP Configuration Guide, Release 12.4*.

## DHCP Server and Switch Stacks

The DHCP binding database is managed on the stack master. When a new stack master is assigned, the new master downloads the saved binding database from the TFTP server. When a switchover happens, the new active stack master will use its database file that has been synced from the old active stack master using the SSO function. The IP addresses associated with the lost bindings are released. You should configure an automatic backup by using the **ip dhcp database url [timeout seconds | write-delay seconds]** global configuration command.

## Configuring the DHCP Relay Agent

Follow these steps to enable the DHCP relay agent on the switch:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 3</b>	<b>service dhcp</b> <b>Example:</b> Device(config)# <code>service dhcp</code>	Enables the DHCP server and relay agent on your switch. By default, this feature is enabled.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b> Device# <code>show running-config</code>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

**What to do next**

- Checking (validating) the relay agent information
- Configuring the relay agent forwarding policy

## Specifying the Packet Forwarding Address

If the DHCP server and the DHCP clients are on different networks or subnets, you must configure the switch with the **ip helper-address** *address* interface configuration command. The general rule is to configure the command on the Layer 3 interface closest to the client. The address used in the **ip helper-address** command can be a specific DHCP server IP address, or it can be the network address if other DHCP servers are on the destination network segment. Using the network address enables any DHCP server to respond to requests.

Beginning in privileged EXEC mode, follow these steps to specify the packet forwarding address:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<code>enable</code>	Enables privileged EXEC mode.



	Command or Action	Purpose
	<b>Example:</b>  Device> <b>enable</b>	<ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface vlan <i>vlan-id</i></b>  <b>Example:</b>  Device(config)# <b>interface vlan 1</b>	Creates a switch virtual interface by entering a VLAN ID, and enter interface configuration mode.
<b>Step 4</b>	<b>ip address <i>ip-address subnet-mask</i></b>  <b>Example:</b>  Device(config-if)# <b>ip address</b> 192.108.1.27 255.255.255.0	Configures the interface with an IP address and an IP subnet.
<b>Step 5</b>	<b>ip helper-address <i>address</i></b>  <b>Example:</b>  Device(config-if)# <b>ip helper-address</b> 172.16.1.2	<p>Specifies the DHCP packet forwarding address.</p> <p>The helper address can be a specific DHCP server address, or it can be the network address if other DHCP servers are on the destination network segment. Using the network address enables other servers to respond to DHCP requests.</p> <p>If you have multiple servers, you can configure one helper address for each server.</p>
<b>Step 6</b>	<b>end</b>  <b>Example:</b>  Device(config-if)# <b>end</b>	Returns to global configuration mode.
<b>Step 7</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>interface range <i>port-range</i></b></li> <li>• <b>interface <i>interface-id</i></b></li> </ul> <b>Example:</b>  Device(config)# <b>interface</b> gigabitethernet1/0/2	<p>Configures multiple physical ports that are connected to the DHCP clients, and enter interface range configuration mode.</p> <p>or</p> <p>Configures a single physical port that is connected to the DHCP client, and enter interface configuration mode.</p>
<b>Step 8</b>	<b>switchport mode access</b>  <b>Example:</b>	Defines the VLAN membership mode for the port.

	Command or Action	Purpose
	Device(config-if)# switchport mode access	
<b>Step 9</b>	<b>switchport access vlan <i>vlan-id</i></b> <b>Example:</b> Device(config-if)# switchport access vlan 1	Assigns the ports to the same VLAN as configured in Step 2.
<b>Step 10</b>	<b>end</b> <b>Example:</b> Device(config-if)# end	Returns to privileged EXEC mode.
<b>Step 11</b>	<b>show running-config</b> <b>Example:</b> Device# show running-config	Verifies your entries.
<b>Step 12</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# copy running-config startup-config	(Optional) Saves your entries in the configuration file.

## Prerequisites for Configuring DHCP Snooping and Option 82

The prerequisites for DHCP Snooping and Option 82 are as follows:

- You must globally enable DHCP snooping on the switch.
- Before globally enabling DHCP snooping on the switch, make sure that the devices acting as the DHCP server and the DHCP relay agent are configured and enabled.
- If you want the switch to respond to DHCP requests, it must be configured as a DHCP server.
- Before configuring the DHCP snooping information option on your switch, be sure to configure the device that is acting as the DHCP server. You must specify the IP addresses that the DHCP server can assign or exclude, or you must configure DHCP options for these devices.
- For DHCP snooping to function properly, all DHCP servers must be connected to the switch through trusted interfaces. In a service-provider network, a trusted interface is connected to a port on a device in the same network.
- You must configure the switch to use the Cisco IOS DHCP server binding database to use it for DHCP snooping.
- To use the DHCP snooping option of accepting packets on untrusted inputs, the switch must be an aggregation switch that receives packets with option-82 information from an edge switch.

- The following prerequisites apply to DHCP snooping binding database configuration:
  - You must configure a destination on the DHCP snooping binding database to use the switch for DHCP snooping.
  - Because both NVRAM and the flash memory have limited storage capacity, we recommend that you store the binding file on a TFTP server.
  - For network-based URLs (such as TFTP and FTP), you must create an empty file at the configured URL before the switch can write bindings to the binding file at that URL. See the documentation for your TFTP server to determine whether you must first create an empty file on the server; some TFTP servers cannot be configured this way.
  - To ensure that the lease time in the database is accurate, we recommend that you enable and configure Network Time Protocol (NTP).
  - If NTP is configured, the switch writes binding changes to the binding file only when the switch system clock is synchronized with NTP.
- Before configuring the DHCP relay agent on your switch, make sure to configure the device that is acting as the DHCP server. You must specify the IP addresses that the DHCP server can assign or exclude, configure DHCP options for devices, or set up the DHCP database agent.
- If you want the switch to relay DHCP packets, the IP address of the DHCP server must be configured on the switch virtual interface (SVI) of the DHCP client.
- If a switch port is connected to a DHCP server, configure a port as trusted by entering the **ip dhcp snooping trust interface** configuration command.
- If a switch port is connected to a DHCP client, configure a port as untrusted by entering the **no ip dhcp snooping trust interface** configuration command.

#### Related Topics

[DHCP Snooping](#), on page 1938

## Enabling the Cisco IOS DHCP Server Database

For procedures to enable and configure the Cisco IOS DHCP server database, see the “DHCP Configuration Task List” section in the “Configuring DHCP” chapter of the Cisco IOS IP Configuration Guide, Release 12.4

## Monitoring DHCP Snooping Information

*Table 146: Commands for Displaying DHCP Information*

<b>show ip dhcp snooping</b>	Displays the DHCP snooping configuration for a switch
<b>show ip dhcp snooping binding</b>	Displays only the dynamically configured bindings in the DHCP snooping binding database, also referred to as a binding table.

<b>show ip dhcp snooping database</b>	Displays the DHCP snooping binding database status and statistics.
<b>show ip dhcp snooping statistics</b>	Displays the DHCP snooping statistics in summary or detail form.
<b>show ip source binding</b>	Display the dynamically and statically configured bindings.



**Note** If DHCP snooping is enabled and an interface changes to the down state, the switch does not delete the statically configured bindings.

## Configuring DHCP Server Port-Based Address Allocation

### Information About Configuring DHCP Server Port-Based Address Allocation

DHCP server port-based address allocation is a feature that enables DHCP to maintain the same IP address on an Ethernet switch port regardless of the attached device client identifier or client hardware address.

When Ethernet switches are deployed in the network, they offer connectivity to the directly connected devices. In some environments, such as on a factory floor, if a device fails, the replacement device must be working immediately in the existing network. With the current DHCP implementation, there is no guarantee that DHCP would offer the same IP address to the replacement device. Control, monitoring, and other software expect a stable IP address associated with each device. If a device is replaced, the address assignment should remain stable even though the DHCP client has changed.

When configured, the DHCP server port-based address allocation feature ensures that the same IP address is always offered to the same connected port even as the client identifier or client hardware address changes in the DHCP messages received on that port. The DHCP protocol recognizes DHCP clients by the client identifier option in the DHCP packet. Clients that do not include the client identifier option are identified by the client hardware address. When you configure this feature, the port name of the interface overrides the client identifier or hardware address and the actual point of connection, the switch port, becomes the client identifier.

In all cases, by connecting the Ethernet cable to the same port, the same IP address is allocated through DHCP to the attached device.

The DHCP server port-based address allocation feature is only supported on a Cisco IOS DHCP server and not a third-party server.

### Default Port-Based Address Allocation Configuration

By default, DHCP server port-based address allocation is disabled.

### Port-Based Address Allocation Configuration Guidelines

- By default, DHCP server port-based address allocation is disabled.

- To restrict assignments from the DHCP pool to preconfigured reservations (unreserved addresses are not offered to the client and other clients are not served by the pool), you can enter the **reserved-only** DHCP pool configuration command.

## Enabling the DHCP Snooping Binding Database Agent

Beginning in privileged EXEC mode, follow these steps to enable and configure the DHCP snooping binding database agent on the switch:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip dhcp snooping database</b> <b>{flash[number]:filename  </b> <b>ftp://user:password@host/filename  </b> <b>http://[[username:password]@]{hostname  </b> <b>host-ip}[/directory] /image-name.tar  </b> <b>rcp://user@host/filename}</b> <b>tftp://host/filename</b> <b>Example:</b> Device(config)# <b>ip dhcp snooping</b> <b>database tftp://10.90.90.90/snooping-rp2</b>	Specifies the URL for the database agent or the binding file by using one of these forms: <ul style="list-style-type: none"> <li><b>flash[number]:filename</b>                (Optional) Use the <i>number</i> parameter to specify the stack member number of the stack master. The range for <i>number</i> is 1 to 9.</li> <li><b>ftp://user:password@host/filename</b></li> <li><b>http://[[username:password]@]{hostname   host-ip}[/directory] /image-name.tar</b></li> <li><b>rcp://user@host/filename</b></li> <li><b>tftp://host/filename</b></li> </ul>
<b>Step 4</b>	<b>ip dhcp snooping database timeout seconds</b> <b>Example:</b> Device(config)# <b>ip dhcp snooping</b> <b>database timeout 300</b>	Specifies (in seconds) how long to wait for the database transfer process to finish before stopping the process.  The default is 300 seconds. The range is 0 to 86400. Use 0 to define an infinite duration, which means to continue trying the transfer indefinitely.

	Command or Action	Purpose
<b>Step 5</b>	<b>ip dhcp snooping database write-delay</b> <i>seconds</i> <b>Example:</b> <pre>Device(config)# ip dhcp snooping database write-delay 15</pre>	Specifies the duration for which the transfer should be delayed after the binding database changes. The range is from 15 to 86400 seconds. The default is 300 seconds (5 minutes).
<b>Step 6</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>ip dhcp snooping binding mac-address vlan</b> <i>vlan-id ip-address interface interface-id</i> <b>expiry seconds</b> <b>Example:</b> <pre>Device# ip dhcp snooping binding 0001.1234.1234 vlan 1 172.20.50.5 interface gi1/1 expiry 1000</pre>	(Optional) Adds binding entries to the DHCP snooping binding database. The <i>vlan-id</i> range is from 1 to 4904. The <i>seconds</i> range is from 1 to 4294967295.  Enter this command for each entry that you add.  Use this command when you are testing or debugging the switch.
<b>Step 8</b>	<b>show ip dhcp snooping database [detail]</b> <b>Example:</b> <pre>Device# show ip dhcp snooping database detail</pre>	Displays the status and statistics of the DHCP snooping binding database agent.
<b>Step 9</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 10</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Enabling DHCP Server Port-Based Address Allocation

Follow these steps to globally enable port-based address allocation and to automatically generate a subscriber identifier on an interface.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip dhcp use subscriber-id client-id</b> <b>Example:</b> Device(config)# <b>ip dhcp use subscriber-id client-id</b>	Configures the DHCP server to globally use the subscriber identifier as the client identifier on all incoming DHCP messages.
<b>Step 4</b>	<b>ip dhcp subscriber-id interface-name</b> <b>Example:</b> Device(config)# <b>ip dhcp subscriber-id interface-name</b>	Automatically generates a subscriber identifier based on the short name of the interface.  A subscriber identifier configured on a specific interface takes precedence over this command.
<b>Step 5</b>	<b>interface interface-id</b> <b>Example:</b> Device(config)# <b>interface gigabitethernet1/0/1</b>	Specifies the interface to be configured, and enter interface configuration mode.
<b>Step 6</b>	<b>ip dhcp server use subscriber-id client-id</b> <b>Example:</b> Device(config-if)# <b>ip dhcp server use subscriber-id client-id</b>	Configures the DHCP server to use the subscriber identifier as the client identifier on all incoming DHCP messages on the interface.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.

	Command or Action	Purpose
<b>Step 9</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

**What to do next**

After enabling DHCP port-based address allocation on the switch, use the **ip dhcp pool** global configuration command to preassign IP addresses and to associate them to clients.

## Monitoring DHCP Server Port-Based Address Allocation

*Table 147: Commands for Displaying DHCP Port-Based Address Allocation Information*

Command	Purpose
<code>show interface interface id</code>	Displays the status and configuration of a specific interface.
<code>show ip dhcp pool</code>	Displays the DHCP address pools.
<code>show ip dhcp binding</code>	Displays address bindings on the Cisco IOS DHCP server.

## Additional References

**Related Documents**

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Command List, All Releases</a>

**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>



**Technical Assistance**

<b>Description</b>	<b>Link</b>
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>





## CHAPTER 108

# Configuring IP Source Guard

IP Source Guard (IPSG) is a security feature that restricts IP traffic on nonrouted, Layer 2 interfaces by filtering traffic based on the DHCP snooping binding database and on manually configured IP source bindings.

This chapter contains the following topics:

- [Finding Feature Information, on page 1957](#)
- [Information About IP Source Guard, on page 1957](#)
- [How to Configure IP Source Guard, on page 1959](#)
- [Monitoring IP Source Guard, on page 1962](#)
- [Additional References, on page 1963](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About IP Source Guard

### IP Source Guard

You can use IP source guard to prevent traffic attacks if a host tries to use the IP address of its neighbor and you can enable IP source guard when DHCP snooping is enabled on an untrusted interface.

After IPSG is enabled on an interface, the switch blocks all IP traffic received on the interface except for DHCP packets allowed by DHCP snooping.

The switch uses a source IP lookup table in hardware to bind IP addresses to ports. For IP and MAC filtering, a combination of source IP and source MAC lookups are used. IP traffic with a source IP address in the binding table is allowed, all other traffic is denied.

The IP source binding table has bindings that are learned by DHCP snooping or are manually configured (static IP source bindings). An entry in this table has an IP address, its associated MAC address, and its associated VLAN number. The switch uses the IP source binding table only when IP source guard is enabled.

IPSG is supported only on Layer 2 ports, including access and trunk ports. You can configure IPSG with source IP address filtering or with source IP and MAC address filtering.

## IP Source Guard for Static Hosts



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**Note** Do not use IPSG (IP source guard) for static hosts on uplink ports or trunk ports.

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IPSG for static hosts extends the IPSG capability to non-DHCP and static environments. The previous IPSG used the entries created by DHCP snooping to validate the hosts connected to a switch. Any traffic received from a host without a valid DHCP binding entry is dropped. This security feature restricts IP traffic on nonrouted Layer 2 interfaces. It filters traffic based on the DHCP snooping binding database and on manually configured IP source bindings. The previous version of IPSG required a DHCP environment for IPSG to work.

IPSG for static hosts allows IPSG to work without DHCP. IPSG for static hosts relies on IP device tracking-table entries to install port ACLs. The switch creates static entries based on ARP requests or other IP packets to maintain the list of valid hosts for a given port. You can also specify the number of hosts allowed to send traffic to a given port. This is equivalent to port security at Layer 3.

IPSG for static hosts also supports dynamic hosts. If a dynamic host receives a DHCP-assigned IP address that is available in the IP DHCP snooping table, the same entry is learned by the IP device tracking table. In a stacked environment, when the master failover occurs, the IP source guard entries for static hosts attached to member ports are retained. When you enter the **show device-tracking databaseEXEC** command, the IP device tracking table displays the entries as ACTIVE.



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**Note** Some IP hosts with multiple network interfaces can inject some invalid packets into a network interface. The invalid packets contain the IP or MAC address for another network interface of the host as the source address. The invalid packets can cause IPSG for static hosts to connect to the host, to learn the invalid IP or MAC address bindings, and to reject the valid bindings. Consult the vendor of the corresponding operating system and the network interface to prevent the host from injecting invalid packets.

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IPSG for static hosts initially learns IP or MAC bindings dynamically through an ACL-based snooping mechanism. IP or MAC bindings are learned from static hosts by ARP and IP packets. They are stored in the device tracking database. When the number of IP addresses that have been dynamically learned or statically configured on a given port reaches a maximum, the hardware drops any packet with a new IP address. To resolve hosts that have moved or gone away for any reason, IPSG for static hosts leverages IP device tracking to age out dynamically learned IP address bindings. This feature can be used with DHCP snooping. Multiple bindings are established on a port that is connected to both DHCP and static hosts. For example, bindings are stored in both the device tracking database as well as in the DHCP snooping binding database.

## IP Source Guard Configuration Guidelines

- You can configure static IP bindings only on nonrouted ports. If you enter the **ip source binding mac-address vlan vlan-id ip-address interface interface-id** global configuration command on a routed interface, this error message appears:

Static IP source binding can only be configured on switch port.

- When IP source guard with source IP filtering is enabled on an interface, DHCP snooping must be enabled on the access VLAN for that interface.
- If you are enabling IP source guard on a trunk interface with multiple VLANs and DHCP snooping is enabled on all the VLANs, the source IP address filter is applied on all the VLANs.



**Note** If IP source guard is enabled and you enable or disable DHCP snooping on a VLAN on the trunk interface, the switch might not properly filter traffic.

- You can enable this feature when 802.1x port-based authentication is enabled.
- When you configure IP source guard smart logging, packets with a source address other than the specified address or an address learned by DHCP are denied, and the packet contents are sent to a NetFlow collector. If you configure this feature, make sure that smart logging is globally enabled.
- In a switch stack, if IP source guard is configured on a stack member interface and you remove the configuration of that switch by entering the **no switch stack-member-number provision** global configuration command, the interface static bindings are removed from the binding table, but they are not removed from the running configuration. If you again provision the switch by entering the **switch stack-member-number provision** command, the binding is restored.

To remove the binding from the running configuration, you must disable IP source guard before entering the **no switch provision** command. The configuration is also removed if the switch reloads while the interface is removed from the binding table.

## How to Configure IP Source Guard

### Enabling IP Source Guard

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device (config)# <b>interface gigabitethernet 1/0/1</b>	Specifies the interface to be configured, and enters interface configuration mode.
<b>Step 4</b>	<b>ip verify source [mac-check ]</b> <b>Example:</b>  Device (config-if)# <b>ip verify source</b>	Enables IP source guard with source IP address filtering.  (Optional) <b>mac-check</b> —Enables IP Source Guard with source IP address and MAC address filtering.
<b>Step 5</b>	<b>exit</b> <b>Example:</b>  Device (config-if)# <b>exit</b>	Returns to global configuration mode.
<b>Step 6</b>	<b>ip source binding <i>mac-address</i> <i>vlan</i> <i>vlan-id</i> <i>ip-address</i> <i>interface</i> <i>interface-id</i></b> <b>Example:</b>  Device (config)# <b>ip source binding 0100.0230.0002 vlan 11 10.0.0.4 interface gigabitethernet1/0/1</b>	Adds a static IP source binding.  Enter this command for each static binding.
<b>Step 7</b>	<b>end</b> <b>Example:</b>  Device (config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show running-config</b> <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Device# <code>copy running-config startup-config</code>	

## Configuring IP Source Guard for Static Hosts on a Layer 2 Access Port

You must configure the `ip device tracking maximum limit-number` interface configuration command globally for IPSG for static hosts to work. If you only configure this command on a port without enabling IP device tracking globally or by setting an IP device tracking maximum on that interface, IPSG with static hosts rejects all the IP traffic from that interface.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>ip device tracking</b> <b>Example:</b> Device(config)# <code>ip device tracking</code>	Turns on the IP host table, and globally enables IP device tracking.
<b>Step 4</b>	<b>interface interface-id</b> <b>Example:</b> Device(config)# <code>interface gigabitethernet 1/0/1</code>	Enters interface configuration mode.
<b>Step 5</b>	<b>switchport mode access</b> <b>Example:</b> Device(config-if)# <code>switchport mode access</code>	Configures a port as access.

	Command or Action	Purpose
<b>Step 6</b>	<b>switchport access vlan</b> <i>vlan-id</i> <b>Example:</b> Device(config-if)# <b>switchport access vlan</b> <b>10</b>	Configures the VLAN for this port.
<b>Step 7</b>	<b>ip verify source</b> [tracking] [ <b>mac-check</b> ] <b>Example:</b> Device(config-if)# <b>ip verify source</b> <b>tracking mac-check</b>	Enables IP source guard with source IP address filtering. (Optional) <b>tracking</b> —Enables IP source guard for static hosts. (Optional) <b>mac-check</b> —Enables MAC address filtering. The command <b>ip verify source tracking mac-check</b> enables IP source guard for static hosts with MAC address filtering.
<b>Step 8</b>	<b>ip device tracking maximum</b> <i>number</i> <b>Example:</b> Device(config-if)# <b>ip device tracking</b> <b>maximum 8</b>	Establishes a maximum limit for the number of static IPs that the IP device tracking table allows on the port. The range is 1 to 10. The maximum number is 10. <b>Note</b> You must configure the <b>ip device tracking maximum limit-number</b> interface configuration command.
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Monitoring IP Source Guard

Table 148: Privileged EXEC show Commands

Command	Purpose
<b>show ip verify source</b> [ <b>interface</b> <i>interface-id</i> ]	Displays the IP source guard configuration on the switch or on a specific interface.
<b>show ip device tracking</b> { <b>all</b>   <b>interface</b> <i>interface-id</i>   <b>ip</b> <i>ip-address</i>   <b>mac</b> <i>mac-address</i> }	Displays information about the entries in the IP device tracking table.



Table 149: Interface Configuration Commands

Command	Purpose
<b>ip verify source tracking</b>	Verifies the data source.

For detailed information about the fields in these displays, see the command reference for this release.

## Additional References

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>





## CHAPTER 109

# Configuring Dynamic ARP Inspection

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- [Additional References, on page 1995](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Restrictions for Dynamic ARP Inspection

This section lists the restrictions and guidelines for configuring Dynamic ARP Inspection on the switch.

- Dynamic ARP inspection is an ingress security feature; it does not perform any egress checking.
- Dynamic ARP inspection is not effective for hosts connected to switches that do not support dynamic ARP inspection or that do not have this feature enabled. Because man-in-the-middle attacks are limited to a single Layer 2 broadcast domain, separate the domain with dynamic ARP inspection checks from the one with no checking. This action secures the ARP caches of hosts in the domain enabled for dynamic ARP inspection.
- Dynamic ARP inspection depends on the entries in the DHCP snooping binding database to verify IP-to-MAC address bindings in incoming ARP requests and ARP responses. Make sure to enable DHCP snooping to permit ARP packets that have dynamically assigned IP addresses.

When DHCP snooping is disabled or in non-DHCP environments, use ARP ACLs to permit or to deny packets.

- Dynamic ARP inspection is supported on access ports, trunk ports, and EtherChannel ports.



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**Note** Do not enable Dynamic ARP inspection on RSPAN VLANs. If Dynamic ARP inspection is enabled on RSPAN VLANs, Dynamic ARP inspection packets might not reach the RSPAN destination port.

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- A physical port can join an EtherChannel port channel only when the trust state of the physical port and the channel port match. Otherwise, the physical port remains suspended in the port channel. A port channel inherits its trust state from the first physical port that joins the channel. Consequently, the trust state of the first physical port need not match the trust state of the channel.

Conversely, when you change the trust state on the port channel, the switch configures a new trust state on all the physical ports that comprise the channel.

- The rate limit is calculated separately on each switch in a switch stack. For a cross-stack EtherChannel, this means that the actual rate limit might be higher than the configured value. For example, if you set the rate limit to 30 pps on an EtherChannel that has one port on switch 1 and one port on switch 2, each port can receive packets at 29 pps without causing the EtherChannel to become error-disabled.
- The operating rate for the port channel is cumulative across all the physical ports within the channel. For example, if you configure the port channel with an ARP rate-limit of 400 pps, all the interfaces combined on the channel receive an aggregate 400 pps. The rate of incoming ARP packets on EtherChannel ports is equal to the sum of the incoming rate of packets from all the channel members. Configure the rate limit for EtherChannel ports only after examining the rate of incoming ARP packets on the channel-port members.

The rate of incoming packets on a physical port is checked against the port-channel configuration rather than the physical-ports configuration. The rate-limit configuration on a port channel is independent of the configuration on its physical ports.

If the EtherChannel receives more ARP packets than the configured rate, the channel (including all physical ports) is placed in the error-disabled state.

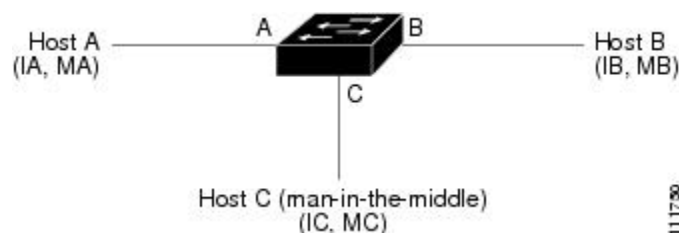
- Make sure to limit the rate of ARP packets on incoming trunk ports. Configure trunk ports with higher rates to reflect their aggregation and to handle packets across multiple dynamic ARP inspection-enabled VLANs. You also can use the **ip arp inspection limit none** interface configuration command to make the rate unlimited. A high rate-limit on one VLAN can cause a denial-of-service attack to other VLANs when the software places the port in the error-disabled state.
- When you enable dynamic ARP inspection on the switch, policers that were configured to police ARP traffic are no longer effective. The result is that all ARP traffic is sent to the CPU.

## Understanding Dynamic ARP Inspection

ARP provides IP communication within a Layer 2 broadcast domain by mapping an IP address to a MAC address. For example, Host B wants to send information to Host A but does not have the MAC address of Host A in its ARP cache. Host B generates a broadcast message for all hosts within the broadcast domain to obtain the MAC address associated with the IP address of Host A. All hosts within the broadcast domain receive the ARP request, and Host A responds with its MAC address. However, because ARP allows a gratuitous reply from a host even if an ARP request was not received, an ARP spoofing attack and the poisoning of ARP caches can occur. After the attack, all traffic from the device under attack flows through the attacker's computer and then to the router, switch, or host.

A malicious user can attack hosts, switches, and routers connected to your Layer 2 network by poisoning the ARP caches of systems connected to the subnet and by intercepting traffic intended for other hosts on the subnet. Figure 26-1 shows an example of ARP cache poisoning.

**Figure 123: ARP Cache Poisoning**



Hosts A, B, and C are connected to the switch on interfaces A, B and C, all of which are on the same subnet. Their IP and MAC addresses are shown in parentheses; for example, Host A uses IP address IA and MAC address MA. When Host A needs to communicate to Host B at the IP layer, it broadcasts an ARP request for the MAC address associated with IP address IB. When the switch and Host B receive the ARP request, they populate their ARP caches with an ARP binding for a host with the IP address IA and a MAC address MA; for example, IP address IA is bound to MAC address MA. When Host B responds, the switch and Host A populate their ARP caches with a binding for a host with the IP address IB and the MAC address MB.

Host C can poison the ARP caches of the switch, Host A, and Host B by broadcasting forged ARP responses with bindings for a host with an IP address of IA (or IB) and a MAC address of MC. Hosts with poisoned ARP caches use the MAC address MC as the destination MAC address for traffic intended for IA or IB. This means that Host C intercepts that traffic. Because Host C knows the true MAC addresses associated with IA and IB, it can forward the intercepted traffic to those hosts by using the correct MAC address as the destination. Host C has inserted itself into the traffic stream from Host A to Host B, the classic *man-in-the-middle* attack.

Dynamic ARP inspection is a security feature that validates ARP packets in a network. It intercepts, logs, and discards ARP packets with invalid IP-to-MAC address bindings. This capability protects the network from certain man-in-the-middle attacks.

Dynamic ARP inspection ensures that only valid ARP requests and responses are relayed. The switch performs these activities:

- Intercepts all ARP requests and responses on untrusted ports
- Verifies that each of these intercepted packets has a valid IP-to-MAC address binding before updating the local ARP cache or before forwarding the packet to the appropriate destination
- Drops invalid ARP packets

Dynamic ARP inspection determines the validity of an ARP packet based on valid IP-to-MAC address bindings stored in a trusted database, the DHCP snooping binding database. This database is built by DHCP snooping if DHCP snooping is enabled on the VLANs and on the switch. If the ARP packet is received on a trusted interface, the switch forwards the packet without any checks. On untrusted interfaces, the switch forwards the packet only if it is valid.

You enable dynamic ARP inspection on a per-VLAN basis by using the **ip arp inspection vlan *vlan-range*** global configuration command.

In non-DHCP environments, dynamic ARP inspection can validate ARP packets against user-configured ARP access control lists (ACLs) for hosts with statically configured IP addresses. You define an ARP ACL by using the **arp access-list *acl-name*** global configuration command.

You can configure dynamic ARP inspection to drop ARP packets when the IP addresses in the packets are invalid or when the MAC addresses in the body of the ARP packets do not match the addresses specified in the Ethernet header. Use the **ip arp inspection validate {[src-mac] [dst-mac] [ip]}** global configuration command.

## Interface Trust States and Network Security

Dynamic ARP inspection associates a trust state with each interface on the switch. Packets arriving on trusted interfaces bypass all dynamic ARP inspection validation checks, and those arriving on untrusted interfaces undergo the dynamic ARP inspection validation process.

In a typical network configuration, you configure all switch ports connected to host ports as untrusted and configure all switch ports connected to switches as trusted. With this configuration, all ARP packets entering the network from a given switch bypass the security check. No other validation is needed at any other place in the VLAN or in the network. You configure the trust setting by using the **ip arp inspection trust interface** configuration command.

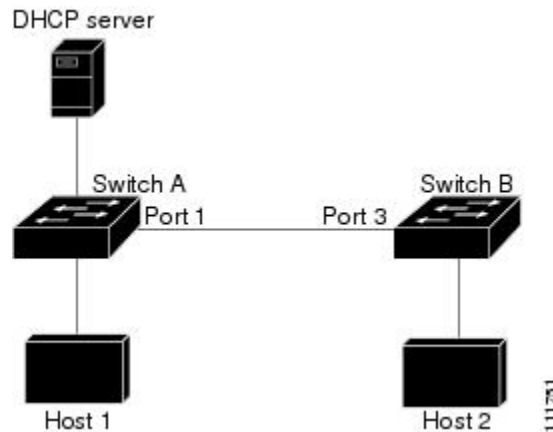


### Caution

Use the trust state configuration carefully. Configuring interfaces as untrusted when they should be trusted can result in a loss of connectivity.

In the following figure, assume that both Switch A and Switch B are running dynamic ARP inspection on the VLAN that includes Host 1 and Host 2. If Host 1 and Host 2 acquire their IP addresses from the DHCP server connected to Switch A, only Switch A binds the IP-to-MAC address of Host 1. Therefore, if the interface between Switch A and Switch B is untrusted, the ARP packets from Host 1 are dropped by Switch B. Connectivity between Host 1 and Host 2 is lost.

Figure 124: ARP Packet Validation on a VLAN Enabled for Dynamic ARP Inspection



Configuring interfaces to be trusted when they are actually untrusted leaves a security hole in the network. If Switch A is not running dynamic ARP inspection, Host 1 can easily poison the ARP cache of Switch B (and Host 2, if the link between the switches is configured as trusted). This condition can occur even though Switch B is running dynamic ARP inspection.

Dynamic ARP inspection ensures that hosts (on untrusted interfaces) connected to a switch running dynamic ARP inspection do not poison the ARP caches of other hosts in the network. However, dynamic ARP inspection does not prevent hosts in other portions of the network from poisoning the caches of the hosts that are connected to a switch running dynamic ARP inspection.

In cases in which some switches in a VLAN run dynamic ARP inspection and other switches do not, configure the interfaces connecting such switches as untrusted. However, to validate the bindings of packets from nondynamic ARP inspection switches, configure the switch running dynamic ARP inspection with ARP ACLs. When you cannot determine such bindings, at Layer 3, isolate switches running dynamic ARP inspection from switches not running dynamic ARP inspection switches.



**Note** Depending on the setup of the DHCP server and the network, it might not be possible to validate a given ARP packet on all switches in the VLAN.

## Rate Limiting of ARP Packets

The switch CPU performs dynamic ARP inspection validation checks; therefore, the number of incoming ARP packets is rate-limited to prevent a denial-of-service attack. By default, the rate for untrusted interfaces is 15 packets per second (pps). Trusted interfaces are not rate-limited. You can change this setting by using the **ip arp inspection limit** interface configuration command.

When the rate of incoming ARP packets exceeds the configured limit, the switch places the port in the error-disabled state. The port remains in that state until you intervene. You can use the **errdisable recovery** global configuration command to enable error disable recovery so that ports automatically emerge from this state after a specified timeout period.



**Note** The rate limit for an EtherChannel is applied separately to each switch in a stack. For example, if a limit of 20 pps is configured on the EtherChannel, each switch with ports in the EtherChannel can carry up to 20 pps. If any switch exceeds the limit, the entire EtherChannel is placed into the error-disabled state.

## Relative Priority of ARP ACLs and DHCP Snooping Entries

Dynamic ARP inspection uses the DHCP snooping binding database for the list of valid IP-to-MAC address bindings.

ARP ACLs take precedence over entries in the DHCP snooping binding database. The switch uses ACLs only if you configure them by using the **ip arp inspection filter vlan** global configuration command. The switch first compares ARP packets to user-configured ARP ACLs. If the ARP ACL denies the ARP packet, the switch also denies the packet even if a valid binding exists in the database populated by DHCP snooping.

## Logging of Dropped Packets

When the switch drops a packet, it places an entry in the log buffer and then generates system messages on a rate-controlled basis. After the message is generated, the switch clears the entry from the log buffer. Each log entry contains flow information, such as the receiving VLAN, the port number, the source and destination IP addresses, and the source and destination MAC addresses.

You use the **ip arp inspection log-buffer** global configuration command to configure the number of entries in the buffer and the number of entries needed in the specified interval to generate system messages. You specify the type of packets that are logged by using the **ip arp inspection vlan logging** global configuration command.

## Default Dynamic ARP Inspection Configuration

Feature	Default Settings
Dynamic ARP inspection	Disabled on all VLANs.
Interface trust state	All interfaces are untrusted.
Rate limit of incoming ARP packets	The rate is 15 pps on untrusted interfaces, assuming that the network is a switched network with a host connecting to as many as 15 new hosts per second.  The rate is unlimited on all trusted interfaces.  The burst interval is 1 second.
ARP ACLs for non-DHCP environments	No ARP ACLs are defined.
Validation checks	No checks are performed.



Feature	Default Settings
Log buffer	<p>When dynamic ARP inspection is enabled, all denied or dropped ARP packets are logged.</p> <p>The number of entries in the log is 32.</p> <p>The number of system messages is limited to 5 per second.</p> <p>The logging-rate interval is 1 second.</p>
Per-VLAN logging	All denied or dropped ARP packets are logged.

## Relative Priority of ARP ACLs and DHCP Snooping Entries

Dynamic ARP inspection uses the DHCP snooping binding database for the list of valid IP-to-MAC address bindings.

ARP ACLs take precedence over entries in the DHCP snooping binding database. The switch uses ACLs only if you configure them by using the `ip arp inspection filter vlan` global configuration command. The switch first compares ARP packets to user-configured ARP ACLs. If the ARP ACL denies the ARP packet, the switch also denies the packet even if a valid binding exists in the database populated by DHCP snooping.

## Configuring ARP ACLs for Non-DHCP Environments

This procedure shows how to configure dynamic ARP inspection when Switch B shown in Figure 2 does not support dynamic ARP inspection or DHCP snooping.

If you configure port 1 on Switch A as trusted, a security hole is created because both Switch A and Host 1 could be attacked by either Switch B or Host 2. To prevent this possibility, you must configure port 1 on Switch A as untrusted. To permit ARP packets from Host 2, you must set up an ARP ACL and apply it to VLAN 1. If the IP address of Host 2 is not static (it is impossible to apply the ACL configuration on Switch A) you must separate Switch A from Switch B at Layer 3 and use a router to route packets between them.

Follow these steps to configure an ARP ACL on Switch A. This procedure is required in non-DHCP environments.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 3</b>	<code>arp access-list <i>acl-name</i></code>	<p>Defines an ARP ACL, and enters ARP access-list configuration mode. By default, no ARP access lists are defined.</p> <p><b>Note</b> At the end of the ARP access list, there is an implicit <b>deny ip any mac any</b> command.</p>
<b>Step 4</b>	<code>permit ip host <i>sender-ip</i> mac host <i>sender-mac</i></code>	<p>Permits ARP packets from the specified host (Host 2).</p> <ul style="list-style-type: none"> <li>• For <i>sender-ip</i>, enter the IP address of Host 2.</li> <li>• For <i>sender-mac</i>, enter the MAC address of Host 2.</li> </ul>
<b>Step 5</b>	<code>exit</code>	Returns to global configuration mode.
<b>Step 6</b>	<code>ip arp inspection filter <i>arp-acl-name</i> vlan <i>vlan-range</i> [static]</code>	<p>Applies ARP ACL to the VLAN. By default, no defined ARP ACLs are applied to any VLAN.</p> <ul style="list-style-type: none"> <li>• For <i>arp-acl-name</i>, specify the name of the ACL created in Step 2.</li> <li>• For <i>vlan-range</i>, specify the VLAN that the switches and hosts are in. You can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094.</li> <li>• (Optional) Specify <b>static</b> to treat implicit denies in the ARP ACL as explicit denies and to drop packets that do not match any previous clauses in the ACL. DHCP bindings are not used.</li> </ul> <p>If you do not specify this keyword, it means that there is no explicit deny in the ACL that denies the packet, and DHCP bindings determine whether a packet is permitted or denied if the packet does not match any clauses in the ACL.</p> <p>ARP packets containing only IP-to-MAC address bindings are compared against the</p>

	Command or Action	Purpose
		ACL. Packets are permitted only if the access list permits them.
<b>Step 7</b>	<b>interface</b> <i>interface-id</i>	Specifies Switch A interface that is connected to Switch B, and enters the interface configuration mode.
<b>Step 8</b>	<b>no ip arp inspection trust</b>	Configures Switch A interface that is connected to Switch B as untrusted.  By default, all interfaces are untrusted.  For untrusted interfaces, the switch intercepts all ARP requests and responses. It verifies that the intercepted packets have valid IP-to-MAC address bindings before updating the local cache and before forwarding the packet to the appropriate destination. The switch drops invalid packets and logs them in the log buffer according to the logging configuration specified with the <b>ip arp inspection vlan logging</b> global configuration command.
<b>Step 9</b>	<b>end</b>	Returns to privileged EXEC mode.
<b>Step 10</b>	Use the following show commands: <ul style="list-style-type: none"> <li>• <b>show arp access-list</b> <i>acl-name</i></li> <li>• <b>show ip arp inspection vlan</b> <i>vlan-range</i></li> <li>• <b>show ip arp inspection interfaces</b></li> </ul>	Verifies your entries.
<b>Step 11</b>	<b>show running-config</b> <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 12</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring Dynamic ARP Inspection in DHCP Environments

### Before you begin

This procedure shows how to configure dynamic ARP inspection when two switches support this feature. Host 1 is connected to Switch A, and Host 2 is connected to Switch B. Both switches are running dynamic

ARP inspection on VLAN 1 where the hosts are located. A DHCP server is connected to Switch A. Both hosts acquire their IP addresses from the same DHCP server. Therefore, Switch A has the bindings for Host 1 and Host 2, and Switch B has the binding for Host 2.



**Note** Dynamic ARP inspection depends on the entries in the DHCP snooping binding database to verify IP-to-MAC address bindings in incoming ARP requests and ARP responses. Make sure to enable DHCP snooping to permit ARP packets that have dynamically assigned IP addresses.

Follow these steps to configure dynamic ARP inspection. You must perform this procedure on both switches. This procedure is required.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>show cdp neighbors</b> <b>Example:</b> Device (config-if) # <b>show cdp neighbors</b>	Verify the connection between the switches.
<b>Step 3</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 4</b>	<b>ip arp inspection vlan <i>vlan-range</i></b> <b>Example:</b> Device (config) # <b>ip arp inspection vlan 1</b>	Enable dynamic ARP inspection on a per-VLAN basis. By default, dynamic ARP inspection is disabled on all VLANs. For <i>vlan-range</i> , specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094. Specify the same VLAN ID for both switches.
<b>Step 5</b>	<b>Interface <i>interface-id</i></b> <b>Example:</b> Device (config) # <b>interface gigabitethernet1/0/1</b>	Specifies the interface connected to the other switch, and enter interface configuration mode.
<b>Step 6</b>	<b>ip arp inspection trust</b> <b>Example:</b> Device (config-if) # <b>ip arp inspection trust</b>	Configures the connection between the switches as trusted. By default, all interfaces are untrusted.

	Command or Action	Purpose
		<p>The switch does not check ARP packets that it receives from the other switch on the trusted interface. It simply forwards the packets.</p> <p>For untrusted interfaces, the switch intercepts all ARP requests and responses. It verifies that the intercepted packets have valid IP-to-MAC address bindings before updating the local cache and before forwarding the packet to the appropriate destination. The switch drops invalid packets and logs them in the log buffer according to the logging configuration specified with the <code>ip arp inspection vlan logging global</code> configuration command.</p>
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device (config-if) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show ip arp inspection interfaces</b> <b>Example:</b>	Verifies the dynamic ARP inspection configuration on interfaces.
<b>Step 9</b>	<b>show ip arp inspection vlan <i>vlan-range</i></b> <b>Example:</b> Device (config-if) # <b>show ip arp inspection vlan 1</b>	Verifies the dynamic ARP inspection configuration on VLAN.
<b>Step 10</b>	<b>show ip dhcp snooping binding</b> <b>Example:</b> Device (config-if) # <b>show ip dhcp snooping binding</b>	Verifies the DHCP bindings.
<b>Step 11</b>	<b>show ip arp inspection statistics vlan <i>vlan-range</i></b> <b>Example:</b> Device (config-if) # <b>show ip arp inspection statistics vlan 1</b>	Checks the dynamic ARP inspection statistics on VLAN.
<b>Step 12</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 13</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

## Limiting the Rate of Incoming ARP Packets

The switch CPU performs dynamic ARP inspection validation checks; therefore, the number of incoming ARP packets is rate-limited to prevent a denial-of-service attack.

When the rate of incoming ARP packets exceeds the configured limit, the switch places the port in the error-disabled state. The port remains in that state until you enable error-disabled recovery so that ports automatically emerge from this state after a specified timeout period.



**Note** Unless you configure a rate limit on an interface, changing the trust state of the interface also changes its rate limit to the default value for that trust state. After you configure the rate limit, the interface retains the rate limit even when its trust state is changed. If you enter the **no ip arp inspection limit** interface configuration command, the interface reverts to its default rate limit.

Follow these steps to limit the rate of incoming ARP packets. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>interface-id</i>	Specifies the interface to be rate-limited, and enter interface configuration mode.
<b>Step 4</b>	<b>ip arp inspection limit</b> {rate pps [burst interval seconds]   none}	Limits the rate of incoming ARP requests and responses on the interface. The default rate is 15 pps on untrusted interfaces and unlimited on trusted interfaces. The burst interval is 1 second.  The keywords have these meanings: <ul style="list-style-type: none"> <li>• For <b>ratepps</b>, specify an upper limit for the number of incoming packets processed per second. The range is 0 to 2048 pps.</li> <li>• (Optional) For <b>burst intervalseconds</b>, specify the consecutive interval in</li> </ul>

	Command or Action	Purpose
		seconds, over which the interface is monitored for a high rate of ARP packets. The range is 1 to 15.  • For <b>rate none</b> , specify no upper limit for the rate of incoming ARP packets that can be processed.
<b>Step 5</b>	<b>exit</b>	Returns to global configuration mode.
<b>Step 6</b>	Use the following commands:  • <b>errdisable detect cause arp-inspection</b> • <b>errdisable recovery cause arp-inspection</b> • <b>errdisable recovery interval interval</b>	(Optional) Enables error recovery from the dynamic ARP inspection error-disabled state, and configure the dynamic ARP inspection recover mechanism variables.  By default, recovery is disabled, and the recovery interval is 300 seconds.  For <b>interval interval</b> , specify the time in seconds to recover from the error-disabled state. The range is 30 to 86400.
<b>Step 7</b>	<b>exit</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	Use the following show commands:  • <b>show ip arp inspection interfaces</b> • <b>show errdisable recovery</b>	Verifies your settings.
<b>Step 9</b>	<b>show running-config</b>  <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 10</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Performing Dynamic ARP Inspection Validation Checks

Dynamic ARP inspection intercepts, logs, and discards ARP packets with invalid IP-to-MAC address bindings. You can configure the switch to perform additional checks on the destination MAC address, the sender and target IP addresses, and the source MAC address.

Follow these steps to perform specific checks on incoming ARP packets. This procedure is optional.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip arp inspection validate {[src-mac] [dst-mac] [ip]}</b>	Performs a specific check on incoming ARP packets. By default, no checks are performed. The keywords have these meanings: <ul style="list-style-type: none"> <li>• For <b>src-mac</b>, check the source MAC address in the Ethernet header against the sender MAC address in the ARP body. This check is performed on both ARP requests and responses. When enabled, packets with different MAC addresses are classified as invalid and are dropped.</li> <li>• For <b>dst-mac</b>, check the destination MAC address in the Ethernet header against the target MAC address in ARP body. This check is performed for ARP responses. When enabled, packets with different MAC addresses are classified as invalid and are dropped.</li> <li>• For <b>ip</b>, check the ARP body for invalid and unexpected IP addresses. Addresses include 0.0.0.0, 255.255.255.255, and all IP multicast addresses. Sender IP addresses are checked in all ARP requests and responses, and target IP addresses are checked only in ARP responses.</li> </ul> You must specify at least one of the keywords. Each command overrides the configuration of the previous command; that is, if a command enables src and dst mac validations, and a second command enables IP validation only, the src and dst mac validations are disabled as a result of the second command.
<b>Step 4</b>	<b>exit</b>	Returns to privileged EXEC mode.



	Command or Action	Purpose
Step 5	<code>show ip arp inspection vlan <i>vlan-range</i></code>	Verifies your settings.
Step 6	<b>show running-config</b> <b>Example:</b> Device# <code>show running-config</code>	Verifies your entries.
Step 7	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Monitoring DAI

To monitor DAI, use the following commands:

Command	Description
<code>clear ip arp inspection statistics</code>	Clears dynamic ARP inspection statistics.
<code>show ip arp inspection statistics [vlan <i>vlan-range</i>]</code>	Displays statistics for forwarded, dropped, MAC validation failure, IP validation failure, ACL permitted and denied, and DHCP permitted and denied packets for the specified VLAN. If no VLANs are specified or if a range is specified, displays information only for VLANs with dynamic ARP inspection enabled (active).
<code>clear ip arp inspection log</code>	Clears the dynamic ARP inspection log buffer.
<code>show ip arp inspection log</code>	Displays the configuration and contents of the dynamic ARP inspection log buffer.

For the `show ip arp inspection statistics` command, the switch increments the number of forwarded packets for each ARP request and response packet on a trusted dynamic ARP inspection port. The switch increments the number of ACL or DHCP permitted packets for each packet that is denied by source MAC, destination MAC, or IP validation checks, and the switch increments the appropriate.

## Verifying the DAI Configuration

To display and verify the DAI configuration, use the following commands:

Command	Description
<code>show arp access-list [<i>acl-name</i>]</code>	Displays detailed information about ARP ACLs.

Command	Description
<code>show ip arp inspection interfaces [interface-id]</code>	Displays the trust state and the rate limit of ARP packets for the specified interface or all interfaces.
<code>show ip arp inspection vlan <i>vlan-range</i></code>	Displays the configuration and the operating state of dynamic ARP inspection for the specified VLAN. If no VLANs are specified or if a range is specified, displays information only for VLANs with dynamic ARP inspection enabled (active).

## Additional References

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Restrictions for Dynamic ARP Inspection

This section lists the restrictions and guidelines for configuring Dynamic ARP Inspection on the switch.

- Dynamic ARP inspection is an ingress security feature; it does not perform any egress checking.
- Dynamic ARP inspection is not effective for hosts connected to switches that do not support dynamic ARP inspection or that do not have this feature enabled. Because man-in-the-middle attacks are limited to a single Layer 2 broadcast domain, separate the domain with dynamic ARP inspection checks from the one with no checking. This action secures the ARP caches of hosts in the domain enabled for dynamic ARP inspection.
- Dynamic ARP inspection depends on the entries in the DHCP snooping binding database to verify IP-to-MAC address bindings in incoming ARP requests and ARP responses. Make sure to enable DHCP snooping to permit ARP packets that have dynamically assigned IP addresses.  
  
When DHCP snooping is disabled or in non-DHCP environments, use ARP ACLs to permit or to deny packets.
- Dynamic ARP inspection is supported on access ports, trunk ports, and EtherChannel ports.



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**Note** Do not enable Dynamic ARP inspection on RSPAN VLANs. If Dynamic ARP inspection is enabled on RSPAN VLANs, Dynamic ARP inspection packets might not reach the RSPAN destination port.

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- A physical port can join an EtherChannel port channel only when the trust state of the physical port and the channel port match. Otherwise, the physical port remains suspended in the port channel. A port channel inherits its trust state from the first physical port that joins the channel. Consequently, the trust state of the first physical port need not match the trust state of the channel.  
  
Conversely, when you change the trust state on the port channel, the switch configures a new trust state on all the physical ports that comprise the channel.
- The rate limit is calculated separately on each switch in a switch stack. For a cross-stack EtherChannel, this means that the actual rate limit might be higher than the configured value. For example, if you set the rate limit to 30 pps on an EtherChannel that has one port on switch 1 and one port on switch 2, each port can receive packets at 29 pps without causing the EtherChannel to become error-disabled.

- The operating rate for the port channel is cumulative across all the physical ports within the channel. For example, if you configure the port channel with an ARP rate-limit of 400 pps, all the interfaces combined on the channel receive an aggregate 400 pps. The rate of incoming ARP packets on EtherChannel ports is equal to the sum of the incoming rate of packets from all the channel members. Configure the rate limit for EtherChannel ports only after examining the rate of incoming ARP packets on the channel-port members.

The rate of incoming packets on a physical port is checked against the port-channel configuration rather than the physical-ports configuration. The rate-limit configuration on a port channel is independent of the configuration on its physical ports.

If the EtherChannel receives more ARP packets than the configured rate, the channel (including all physical ports) is placed in the error-disabled state.

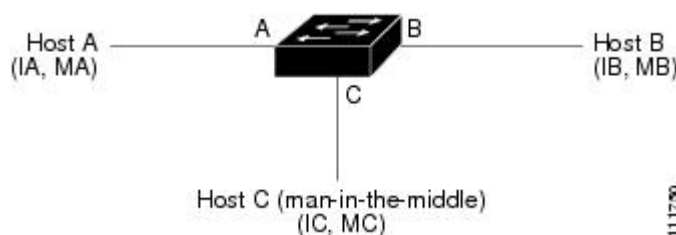
- Make sure to limit the rate of ARP packets on incoming trunk ports. Configure trunk ports with higher rates to reflect their aggregation and to handle packets across multiple dynamic ARP inspection-enabled VLANs. You also can use the **ip arp inspection limit none** interface configuration command to make the rate unlimited. A high rate-limit on one VLAN can cause a denial-of-service attack to other VLANs when the software places the port in the error-disabled state.
- When you enable dynamic ARP inspection on the switch, policers that were configured to police ARP traffic are no longer effective. The result is that all ARP traffic is sent to the CPU.

## Understanding Dynamic ARP Inspection

ARP provides IP communication within a Layer 2 broadcast domain by mapping an IP address to a MAC address. For example, Host B wants to send information to Host A but does not have the MAC address of Host A in its ARP cache. Host B generates a broadcast message for all hosts within the broadcast domain to obtain the MAC address associated with the IP address of Host A. All hosts within the broadcast domain receive the ARP request, and Host A responds with its MAC address. However, because ARP allows a gratuitous reply from a host even if an ARP request was not received, an ARP spoofing attack and the poisoning of ARP caches can occur. After the attack, all traffic from the device under attack flows through the attacker's computer and then to the router, switch, or host.

A malicious user can attack hosts, switches, and routers connected to your Layer 2 network by poisoning the ARP caches of systems connected to the subnet and by intercepting traffic intended for other hosts on the subnet. Figure 26-1 shows an example of ARP cache poisoning.

**Figure 125: ARP Cache Poisoning**



Hosts A, B, and C are connected to the switch on interfaces A, B and C, all of which are on the same subnet. Their IP and MAC addresses are shown in parentheses; for example, Host A uses IP address IA and MAC address MA. When Host A needs to communicate to Host B at the IP layer, it broadcasts an ARP request for the MAC address associated with IP address IB. When the switch and Host B receive the ARP request, they populate their ARP caches with an ARP binding for a host with the IP address IA and a MAC address MA;

for example, IP address IA is bound to MAC address MA. When Host B responds, the switch and Host A populate their ARP caches with a binding for a host with the IP address IB and the MAC address MB.

Host C can poison the ARP caches of the switch, Host A, and Host B by broadcasting forged ARP responses with bindings for a host with an IP address of IA (or IB) and a MAC address of MC. Hosts with poisoned ARP caches use the MAC address MC as the destination MAC address for traffic intended for IA or IB. This means that Host C intercepts that traffic. Because Host C knows the true MAC addresses associated with IA and IB, it can forward the intercepted traffic to those hosts by using the correct MAC address as the destination. Host C has inserted itself into the traffic stream from Host A to Host B, the classic *man-in-the-middle* attack.

Dynamic ARP inspection is a security feature that validates ARP packets in a network. It intercepts, logs, and discards ARP packets with invalid IP-to-MAC address bindings. This capability protects the network from certain man-in-the-middle attacks.

Dynamic ARP inspection ensures that only valid ARP requests and responses are relayed. The switch performs these activities:

- Intercepts all ARP requests and responses on untrusted ports
- Verifies that each of these intercepted packets has a valid IP-to-MAC address binding before updating the local ARP cache or before forwarding the packet to the appropriate destination
- Drops invalid ARP packets

Dynamic ARP inspection determines the validity of an ARP packet based on valid IP-to-MAC address bindings stored in a trusted database, the DHCP snooping binding database. This database is built by DHCP snooping if DHCP snooping is enabled on the VLANs and on the switch. If the ARP packet is received on a trusted interface, the switch forwards the packet without any checks. On untrusted interfaces, the switch forwards the packet only if it is valid.

You enable dynamic ARP inspection on a per-VLAN basis by using the **ip arp inspection vlan *vlan-range*** global configuration command.

In non-DHCP environments, dynamic ARP inspection can validate ARP packets against user-configured ARP access control lists (ACLs) for hosts with statically configured IP addresses. You define an ARP ACL by using the **arp access-list *acl-name*** global configuration command.

You can configure dynamic ARP inspection to drop ARP packets when the IP addresses in the packets are invalid or when the MAC addresses in the body of the ARP packets do not match the addresses specified in the Ethernet header. Use the **ip arp inspection validate {[*src-mac*] [*dst-mac*] [*ip*]}** global configuration command.

## Interface Trust States and Network Security

Dynamic ARP inspection associates a trust state with each interface on the switch. Packets arriving on trusted interfaces bypass all dynamic ARP inspection validation checks, and those arriving on untrusted interfaces undergo the dynamic ARP inspection validation process.

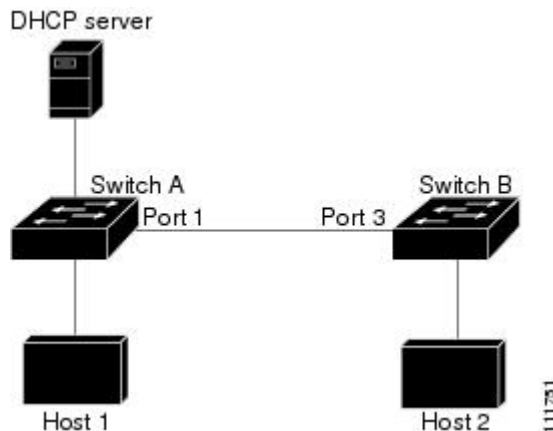
In a typical network configuration, you configure all switch ports connected to host ports as untrusted and configure all switch ports connected to switches as trusted. With this configuration, all ARP packets entering the network from a given switch bypass the security check. No other validation is needed at any other place in the VLAN or in the network. You configure the trust setting by using the **ip arp inspection trust interface** configuration command.

**Caution**

Use the trust state configuration carefully. Configuring interfaces as untrusted when they should be trusted can result in a loss of connectivity.

In the following figure, assume that both Switch A and Switch B are running dynamic ARP inspection on the VLAN that includes Host 1 and Host 2. If Host 1 and Host 2 acquire their IP addresses from the DHCP server connected to Switch A, only Switch A binds the IP-to-MAC address of Host 1. Therefore, if the interface between Switch A and Switch B is untrusted, the ARP packets from Host 1 are dropped by Switch B. Connectivity between Host 1 and Host 2 is lost.

*Figure 126: ARP Packet Validation on a VLAN Enabled for Dynamic ARP Inspection*



Configuring interfaces to be trusted when they are actually untrusted leaves a security hole in the network. If Switch A is not running dynamic ARP inspection, Host 1 can easily poison the ARP cache of Switch B (and Host 2, if the link between the switches is configured as trusted). This condition can occur even though Switch B is running dynamic ARP inspection.

Dynamic ARP inspection ensures that hosts (on untrusted interfaces) connected to a switch running dynamic ARP inspection do not poison the ARP caches of other hosts in the network. However, dynamic ARP inspection does not prevent hosts in other portions of the network from poisoning the caches of the hosts that are connected to a switch running dynamic ARP inspection.

In cases in which some switches in a VLAN run dynamic ARP inspection and other switches do not, configure the interfaces connecting such switches as untrusted. However, to validate the bindings of packets from nondynamic ARP inspection switches, configure the switch running dynamic ARP inspection with ARP ACLs. When you cannot determine such bindings, at Layer 3, isolate switches running dynamic ARP inspection from switches not running dynamic ARP inspection switches.

**Note**

Depending on the setup of the DHCP server and the network, it might not be possible to validate a given ARP packet on all switches in the VLAN.

## Rate Limiting of ARP Packets

The switch CPU performs dynamic ARP inspection validation checks; therefore, the number of incoming ARP packets is rate-limited to prevent a denial-of-service attack. By default, the rate for untrusted interfaces

is 15 packets per second (pps). Trusted interfaces are not rate-limited. You can change this setting by using the **ip arp inspection limit** interface configuration command.

When the rate of incoming ARP packets exceeds the configured limit, the switch places the port in the error-disabled state. The port remains in that state until you intervene. You can use the **errdisable recovery** global configuration command to enable error disable recovery so that ports automatically emerge from this state after a specified timeout period.



**Note** The rate limit for an EtherChannel is applied separately to each switch in a stack. For example, if a limit of 20 pps is configured on the EtherChannel, each switch with ports in the EtherChannel can carry up to 20 pps. If any switch exceeds the limit, the entire EtherChannel is placed into the error-disabled state.

## Relative Priority of ARP ACLs and DHCP Snooping Entries

Dynamic ARP inspection uses the DHCP snooping binding database for the list of valid IP-to-MAC address bindings.

ARP ACLs take precedence over entries in the DHCP snooping binding database. The switch uses ACLs only if you configure them by using the **ip arp inspection filter vlan** global configuration command. The switch first compares ARP packets to user-configured ARP ACLs. If the ARP ACL denies the ARP packet, the switch also denies the packet even if a valid binding exists in the database populated by DHCP snooping.

## Logging of Dropped Packets

When the switch drops a packet, it places an entry in the log buffer and then generates system messages on a rate-controlled basis. After the message is generated, the switch clears the entry from the log buffer. Each log entry contains flow information, such as the receiving VLAN, the port number, the source and destination IP addresses, and the source and destination MAC addresses.

You use the **ip arp inspection log-buffer** global configuration command to configure the number of entries in the buffer and the number of entries needed in the specified interval to generate system messages. You specify the type of packets that are logged by using the **ip arp inspection vlan logging** global configuration command.

## Default Dynamic ARP Inspection Configuration

Feature	Default Settings
Dynamic ARP inspection	Disabled on all VLANs.
Interface trust state	All interfaces are untrusted.
Rate limit of incoming ARP packets	The rate is 15 pps on untrusted interfaces, assuming that the network is a switched network with a host connecting to as many as 15 new hosts per second.  The rate is unlimited on all trusted interfaces.  The burst interval is 1 second.

Feature	Default Settings
ARP ACLs for non-DHCP environments	No ARP ACLs are defined.
Validation checks	No checks are performed.
Log buffer	When dynamic ARP inspection is enabled, all denied or dropped ARP packets are logged.  The number of entries in the log is 32.  The number of system messages is limited to 5 per second.  The logging-rate interval is 1 second.
Per-VLAN logging	All denied or dropped ARP packets are logged.

## Relative Priority of ARP ACLs and DHCP Snooping Entries

Dynamic ARP inspection uses the DHCP snooping binding database for the list of valid IP-to-MAC address bindings.

ARP ACLs take precedence over entries in the DHCP snooping binding database. The switch uses ACLs only if you configure them by using the `ip arp inspection filter vlan global` configuration command. The switch first compares ARP packets to user-configured ARP ACLs. If the ARP ACL denies the ARP packet, the switch also denies the packet even if a valid binding exists in the database populated by DHCP snooping.

## Configuring ARP ACLs for Non-DHCP Environments

This procedure shows how to configure dynamic ARP inspection when Switch B shown in Figure 2 does not support dynamic ARP inspection or DHCP snooping.

If you configure port 1 on Switch A as trusted, a security hole is created because both Switch A and Host 1 could be attacked by either Switch B or Host 2. To prevent this possibility, you must configure port 1 on Switch A as untrusted. To permit ARP packets from Host 2, you must set up an ARP ACL and apply it to VLAN 1. If the IP address of Host 2 is not static (it is impossible to apply the ACL configuration on Switch A) you must separate Switch A from Switch B at Layer 3 and use a router to route packets between them.

Follow these steps to configure an ARP ACL on Switch A. This procedure is required in non-DHCP environments.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>



	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>arp access-list <i>acl-name</i></b>	Defines an ARP ACL, and enters ARP access-list configuration mode. By default, no ARP access lists are defined.  <b>Note</b> At the end of the ARP access list, there is an implicit <b>deny ip any mac any</b> command.
<b>Step 4</b>	<b>permit ip host <i>sender-ip</i> mac host <i>sender-mac</i></b>	Permits ARP packets from the specified host (Host 2). <ul style="list-style-type: none"> <li>• For <i>sender-ip</i>, enter the IP address of Host 2.</li> <li>• For <i>sender-mac</i>, enter the MAC address of Host 2.</li> </ul>
<b>Step 5</b>	<b>exit</b>	Returns to global configuration mode.
<b>Step 6</b>	<b>ip arp inspection filter <i>arp-acl-name</i> vlan <i>vlan-range</i> [static]</b>	Applies ARP ACL to the VLAN. By default, no defined ARP ACLs are applied to any VLAN. <ul style="list-style-type: none"> <li>• For <i>arp-acl-name</i>, specify the name of the ACL created in Step 2.</li> <li>• For <i>vlan-range</i>, specify the VLAN that the switches and hosts are in. You can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094.</li> <li>• (Optional) Specify <b>static</b> to treat implicit denies in the ARP ACL as explicit denies and to drop packets that do not match any previous clauses in the ACL. DHCP bindings are not used.</li> </ul> If you do not specify this keyword, it means that there is no explicit deny in the ACL that denies the packet, and DHCP bindings determine whether a packet is permitted or denied if the packet does not match any clauses in the ACL.

	Command or Action	Purpose
		ARP packets containing only IP-to-MAC address bindings are compared against the ACL. Packets are permitted only if the access list permits them.
<b>Step 7</b>	<b>interface</b> <i>interface-id</i>	Specifies Switch A interface that is connected to Switch B, and enters the interface configuration mode.
<b>Step 8</b>	<b>no ip arp inspection trust</b>	Configures Switch A interface that is connected to Switch B as untrusted.  By default, all interfaces are untrusted.  For untrusted interfaces, the switch intercepts all ARP requests and responses. It verifies that the intercepted packets have valid IP-to-MAC address bindings before updating the local cache and before forwarding the packet to the appropriate destination. The switch drops invalid packets and logs them in the log buffer according to the logging configuration specified with the <b>ip arp inspection vlan logging</b> global configuration command.
<b>Step 9</b>	<b>end</b>	Returns to privileged EXEC mode.
<b>Step 10</b>	Use the following show commands:  <ul style="list-style-type: none"> <li>• <b>show arp access-list</b> <i>acl-name</i></li> <li>• <b>show ip arp inspection vlan</b> <i>vlan-range</i></li> <li>• <b>show ip arp inspection interfaces</b></li> </ul>	Verifies your entries.
<b>Step 11</b>	<b>show running-config</b>  <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 12</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

# Configuring Dynamic ARP Inspection in DHCP Environments

## Before you begin

This procedure shows how to configure dynamic ARP inspection when two switches support this feature. Host 1 is connected to Switch A, and Host 2 is connected to Switch B. Both switches are running dynamic ARP inspection on VLAN 1 where the hosts are located. A DHCP server is connected to Switch A. Both hosts acquire their IP addresses from the same DHCP server. Therefore, Switch A has the bindings for Host 1 and Host 2, and Switch B has the binding for Host 2.



**Note** Dynamic ARP inspection depends on the entries in the DHCP snooping binding database to verify IP-to-MAC address bindings in incoming ARP requests and ARP responses. Make sure to enable DHCP snooping to permit ARP packets that have dynamically assigned IP addresses.

Follow these steps to configure dynamic ARP inspection. You must perform this procedure on both switches. This procedure is required.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>show cdp neighbors</b> <b>Example:</b> Device (config-if) # <b>show cdp neighbors</b>	Verify the connection between the switches.
<b>Step 3</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 4</b>	<b>ip arp inspection vlan <i>vlan-range</i></b> <b>Example:</b> Device (config) # <b>ip arp inspection vlan 1</b>	Enable dynamic ARP inspection on a per-VLAN basis. By default, dynamic ARP inspection is disabled on all VLANs. For <i>vlan-range</i> , specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094. Specify the same VLAN ID for both switches.

	Command or Action	Purpose
<b>Step 5</b>	<b>Interface</b> <i>interface-id</i> <b>Example:</b> Device (config) # <b>interface</b> <b>gigabitethernet1/0/1</b>	Specifies the interface connected to the other switch, and enter interface configuration mode.
<b>Step 6</b>	<b>ip arp inspection trust</b> <b>Example:</b> Device (config-if) # <b>ip arp inspection trust</b>	<p>Configures the connection between the switches as trusted. By default, all interfaces are untrusted.</p> <p>The switch does not check ARP packets that it receives from the other switch on the trusted interface. It simply forwards the packets.</p> <p>For untrusted interfaces, the switch intercepts all ARP requests and responses. It verifies that the intercepted packets have valid IP-to-MAC address bindings before updating the local cache and before forwarding the packet to the appropriate destination. The switch drops invalid packets and logs them in the log buffer according to the logging configuration specified with the <code>ip arp inspection vlan logging global</code> configuration command.</p>
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device (config-if) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show ip arp inspection interfaces</b> <b>Example:</b>	Verifies the dynamic ARP inspection configuration on interfaces.
<b>Step 9</b>	<b>show ip arp inspection vlan</b> <i>vlan-range</i> <b>Example:</b> Device (config-if) # <b>show ip arp inspection vlan 1</b>	Verifies the dynamic ARP inspection configuration on VLAN.
<b>Step 10</b>	<b>show ip dhcp snooping binding</b> <b>Example:</b> Device (config-if) # <b>show ip dhcp snooping binding</b>	Verifies the DHCP bindings.
<b>Step 11</b>	<b>show ip arp inspection statistics vlan</b> <i>vlan-range</i> <b>Example:</b> Device (config-if) # <b>show ip arp inspection statistics vlan 1</b>	Checks the dynamic ARP inspection statistics on VLAN.

	Command or Action	Purpose
<b>Step 12</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 13</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.

## Limiting the Rate of Incoming ARP Packets

The switch CPU performs dynamic ARP inspection validation checks; therefore, the number of incoming ARP packets is rate-limited to prevent a denial-of-service attack.

When the rate of incoming ARP packets exceeds the configured limit, the switch places the port in the error-disabled state. The port remains in that state until you enable error-disabled recovery so that ports automatically emerge from this state after a specified timeout period.



**Note** Unless you configure a rate limit on an interface, changing the trust state of the interface also changes its rate limit to the default value for that trust state. After you configure the rate limit, the interface retains the rate limit even when its trust state is changed. If you enter the **no ip arp inspection limit** interface configuration command, the interface reverts to its default rate limit.

Follow these steps to limit the rate of incoming ARP packets. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>interface-id</i>	Specifies the interface to be rate-limited, and enter interface configuration mode.

	Command or Action	Purpose
Step 4	<b>ip arp inspection limit {rate pps [burst interval seconds]   none}</b>	<p>Limits the rate of incoming ARP requests and responses on the interface. The default rate is 15 pps on untrusted interfaces and unlimited on trusted interfaces. The burst interval is 1 second.</p> <p>The keywords have these meanings:</p> <ul style="list-style-type: none"> <li>• For <b>ratepps</b>, specify an upper limit for the number of incoming packets processed per second. The range is 0 to 2048 pps.</li> <li>• (Optional) For <b>burst intervalseconds</b>, specify the consecutive interval in seconds, over which the interface is monitored for a high rate of ARP packets. The range is 1 to 15.</li> <li>• For <b>rate none</b>, specify no upper limit for the rate of incoming ARP packets that can be processed.</li> </ul>
Step 5	<b>exit</b>	Returns to global configuration mode.
Step 6	<p>Use the following commands:</p> <ul style="list-style-type: none"> <li>• <b>errdisable detect cause arp-inspection</b></li> <li>• <b>errdisable recovery cause arp-inspection</b></li> <li>• <b>errdisable recovery interval interval</b></li> </ul>	<p>(Optional) Enables error recovery from the dynamic ARP inspection error-disabled state, and configure the dynamic ARP inspection recover mechanism variables.</p> <p>By default, recovery is disabled, and the recovery interval is 300 seconds.</p> <p>For <b>interval interval</b>, specify the time in seconds to recover from the error-disabled state. The range is 30 to 86400.</p>
Step 7	<b>exit</b>	Returns to privileged EXEC mode.
Step 8	<p>Use the following show commands:</p> <ul style="list-style-type: none"> <li>• <b>show ip arp inspection interfaces</b></li> <li>• <b>show errdisable recovery</b></li> </ul>	Verifies your settings.
Step 9	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
Step 10	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Device# <code>copy running-config startup-config</code>	

## Performing Dynamic ARP Inspection Validation Checks

Dynamic ARP inspection intercepts, logs, and discards ARP packets with invalid IP-to-MAC address bindings. You can configure the switch to perform additional checks on the destination MAC address, the sender and target IP addresses, and the source MAC address.

Follow these steps to perform specific checks on incoming ARP packets. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>ip arp inspection validate {[src-mac] [dst-mac] [ip]}</b>	Performs a specific check on incoming ARP packets. By default, no checks are performed. The keywords have these meanings: <ul style="list-style-type: none"> <li>• For <b>src-mac</b>, check the source MAC address in the Ethernet header against the sender MAC address in the ARP body. This check is performed on both ARP requests and responses. When enabled, packets with different MAC addresses are classified as invalid and are dropped.</li> <li>• For <b>dst-mac</b>, check the destination MAC address in the Ethernet header against the target MAC address in ARP body. This check is performed for ARP responses. When enabled, packets with different MAC addresses are classified as invalid and are dropped.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>For <b>ip</b>, check the ARP body for invalid and unexpected IP addresses. Addresses include 0.0.0.0, 255.255.255.255, and all IP multicast addresses. Sender IP addresses are checked in all ARP requests and responses, and target IP addresses are checked only in ARP responses.</li> </ul> <p>You must specify at least one of the keywords. Each command overrides the configuration of the previous command; that is, if a command enables src and dst mac validations, and a second command enables IP validation only, the src and dst mac validations are disabled as a result of the second command.</p>
<b>Step 4</b>	<b>exit</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show ip arp inspection vlan</b> <i>vlan-range</i>	Verifies your settings.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Monitoring DAI

To monitor DAI, use the following commands:

Command	Description
<b>clear ip arp inspection statistics</b>	Clears dynamic ARP inspection statistics.
<b>show ip arp inspection statistics</b> [ <b>vlan</b> <i>vlan-range</i> ]	Displays statistics for forwarded, dropped, MAC validation failure, IP validation failure, ACL permitted and denied, and DHCP permitted and denied packets for the specified VLAN. If no VLANs are specified or if a range is specified, displays information only for VLANs with dynamic ARP inspection enabled (active).



Command	Description
<b>clear ip arp inspection log</b>	Clears the dynamic ARP inspection log buffer.
<b>show ip arp inspection log</b>	Displays the configuration and contents of the dynamic ARP inspection log buffer.

For the **show ip arp inspection statistics** command, the switch increments the number of forwarded packets for each ARP request and response packet on a trusted dynamic ARP inspection port. The switch increments the number of ACL or DHCP permitted packets for each packet that is denied by source MAC, destination MAC, or IP validation checks, and the switch increments the appropriate.

## Verifying the DAI Configuration

To display and verify the DAI configuration, use the following commands:

Command	Description
<b>show arp access-list</b> <i>[acl-name]</i>	Displays detailed information about ARP ACLs.
<b>show ip arp inspection interfaces</b> <i>[interface-id]</i>	Displays the trust state and the rate limit of ARP packets for the specified interface or all interfaces.
<b>show ip arp inspection vlan</b> <i>vlan-range</i>	Displays the configuration and the operating state of dynamic ARP inspection for the specified VLAN. If no VLANs are specified or if a range is specified, displays information only for VLANs with dynamic ARP inspection enabled (active).

## Additional References

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>



## CHAPTER 110

# Configuring IEEE 802.1x Port-Based Authentication

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This chapter describes how to configure IEEE 802.1x port-based authentication. IEEE 802.1x authentication prevents unauthorized devices (clients) from gaining access to the network. Unless otherwise noted, the term *switch* refers to a standalone switch or a switch stack.

- [Finding Feature Information, on page 1997](#)
- [Information About 802.1x Port-Based Authentication, on page 1997](#)
- [How to Configure 802.1x Port-Based Authentication, on page 2028](#)
- [Monitoring 802.1x Statistics and Status, on page 2076](#)
- [Additional References for IEEE 802.1x Port-Based Authentication, on page 2077](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About 802.1x Port-Based Authentication

The 802.1x standard defines a client-server-based access control and authentication protocol that prevents unauthorized clients from connecting to a LAN through publicly accessible ports unless they are properly authenticated. The authentication server authenticates each client connected to a switch port before making available any services offered by the switch or the LAN.



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**Note** TACACS is not supported with 802.1x authentication.

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Until the client is authenticated, 802.1x access control allows only Extensible Authentication Protocol over LAN (EAPOL), Cisco Discovery Protocol (CDP), and Spanning Tree Protocol (STP) traffic through the port to which the client is connected. After authentication is successful, normal traffic can pass through the port.

The table shown below lists the maximum number of each client session supported on Catalyst 3850 and Catalyst 3650 switches:

Client session	Maximum sessions supported
Maximum dot1x or MAB client sessions	2000
Maximum web-based authentication sessions	2000
Maximum dot1x sessions with critical-auth VLAN enabled and server re-initialized	2000
Maximum MAB sessions with various session features applied	2000
Maximum dot1x sessions with service templates or session features applied	2000

## Port-Based Authentication Process

To configure IEEE 802.1X port-based authentication, you must enable authentication, authorization, and accounting (AAA) and specify the authentication method list. A method list describes the sequence and authentication method to be queried to authenticate a user.

The AAA process begins with authentication. When 802.1x port-based authentication is enabled and the client supports 802.1x-compliant client software, these events occur:

- If the client identity is valid and the 802.1x authentication succeeds, the switch grants the client access to the network.
- If 802.1x authentication times out while waiting for an EAPOL message exchange and MAC authentication bypass is enabled, the switch can use the client MAC address for authorization. If the client MAC address is valid and the authorization succeeds, the switch grants the client access to the network. If the client MAC address is invalid and the authorization fails, the switch assigns the client to a guest VLAN that provides limited services if a guest VLAN is configured.
- If the switch gets an invalid identity from an 802.1x-capable client and a restricted VLAN is specified, the switch can assign the client to a restricted VLAN that provides limited services.
- If the RADIUS authentication server is unavailable (down) and inaccessible authentication bypass is enabled, the switch grants the client access to the network by putting the port in the critical-authentication state in the RADIUS-configured or the user-specified access VLAN.




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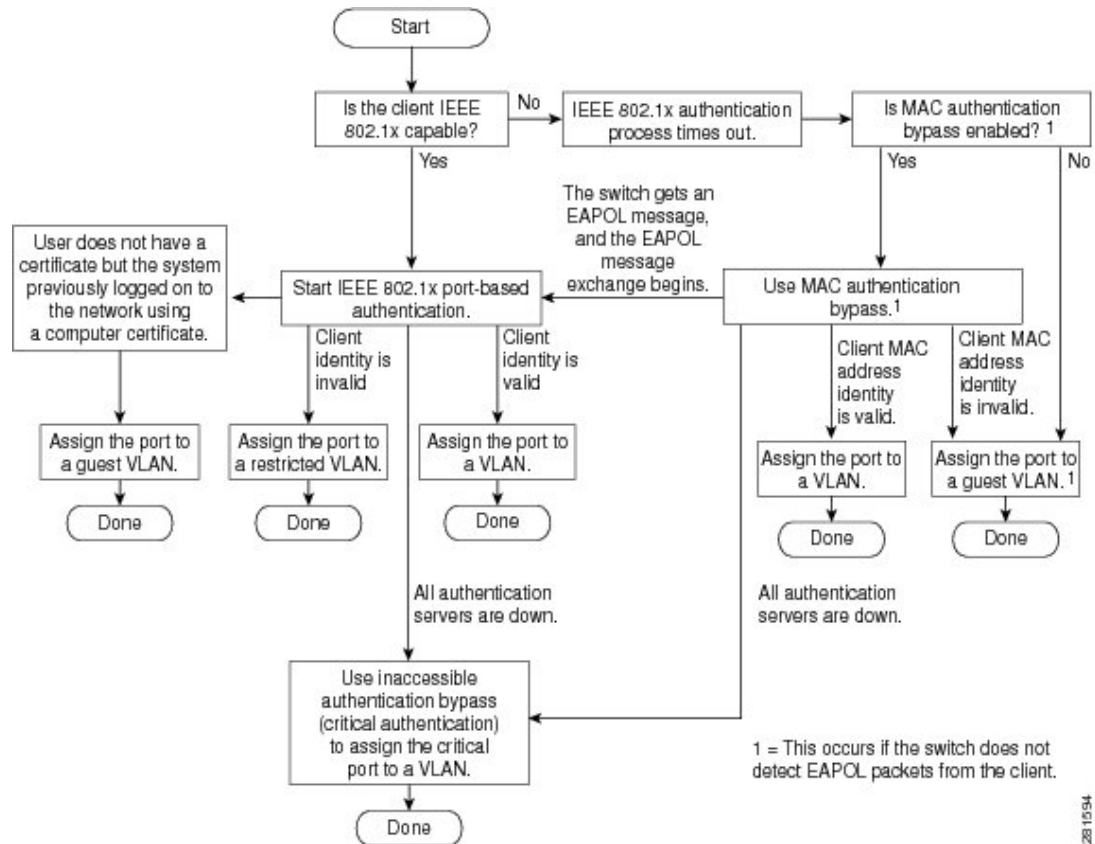
**Note** Inaccessible authentication bypass is also referred to as critical authentication or the AAA fail policy.

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If Multi Domain Authentication (MDA) is enabled on a port, this flow can be used with some exceptions that are applicable to voice authorization.

Figure 127: Authentication Flowchart

This figure shows the authentication process.



The switch re-authenticates a client when one of these situations occurs:

- Periodic re-authentication is enabled, and the re-authentication timer expires.

You can configure the re-authentication timer to use a switch-specific value or to be based on values from the RADIUS server.

After 802.1x authentication using a RADIUS server is configured, the switch uses timers based on the Session-Timeout RADIUS attribute (Attribute[27]) and the Termination-Action RADIUS attribute (Attribute [29]).

The Session-Timeout RADIUS attribute (Attribute[27]) specifies the time after which re-authentication occurs.

The Termination-Action RADIUS attribute (Attribute [29]) specifies the action to take during re-authentication. The actions are *Initialize* and *ReAuthenticate*. When the *Initialize* action is set (the attribute value is *DEFAULT*), the 802.1x session ends, and connectivity is lost during re-authentication. When the *ReAuthenticate* action is set (the attribute value is *RADIUS-Request*), the session is not affected during re-authentication.

- You manually re-authenticate the client by entering the **dot1x re-authenticate interface interface-id** privileged EXEC command.

## Port-Based Authentication Initiation and Message Exchange

During 802.1x authentication, the switch or the client can initiate authentication. If you enable authentication on a port by using the **authentication port-control auto** interface configuration command, the switch initiates authentication when the link state changes from down to up or periodically as long as the port remains up and unauthenticated. The switch sends an EAP-request/identity frame to the client to request its identity. Upon receipt of the frame, the client responds with an EAP-response/identity frame.

However, if during bootup, the client does not receive an EAP-request/identity frame from the switch, the client can initiate authentication by sending an EAPOL-start frame, which prompts the switch to request the client's identity.



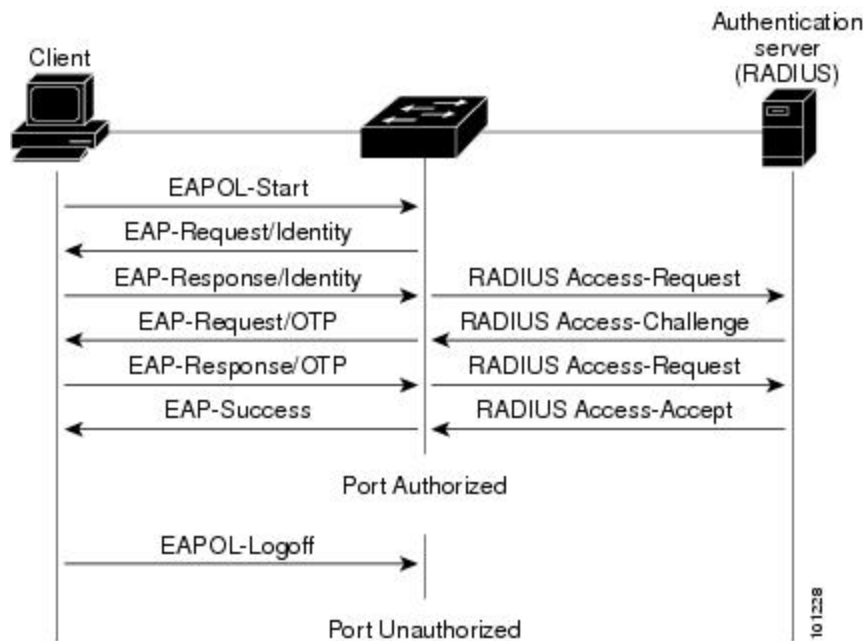
**Note** If 802.1x authentication is not enabled or supported on the network access device, any EAPOL frames from the client are dropped. If the client does not receive an EAP-request/identity frame after three attempts to start authentication, the client sends frames as if the port is in the authorized state. A port in the authorized state effectively means that the client has been successfully authenticated.

When the client supplies its identity, the switch begins its role as the intermediary, passing EAP frames between the client and the authentication server until authentication succeeds or fails. If the authentication succeeds, the switch port becomes authorized. If the authentication fails, authentication can be retried, the port might be assigned to a VLAN that provides limited services, or network access is not granted.

The specific exchange of EAP frames depends on the authentication method being used.

**Figure 128: Message Exchange**

This figure shows a message exchange initiated by the client when the client uses the One-Time-Password (OTP) authentication method with a RADIUS server.

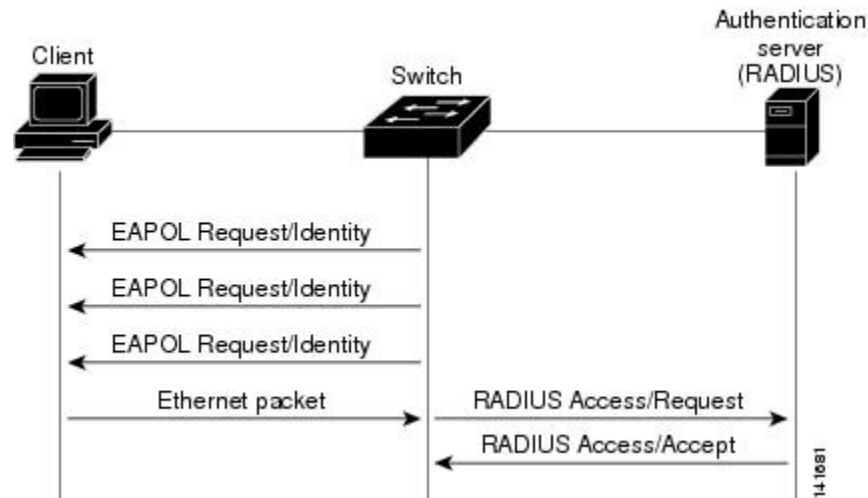


If 802.1x authentication times out while waiting for an EAPOL message exchange and MAC authentication bypass is enabled, the switch can authorize the client when the switch detects an Ethernet packet from the

client. The switch uses the MAC address of the client as its identity and includes this information in the RADIUS-access/request frame that is sent to the RADIUS server. After the server sends the switch the RADIUS-access/accept frame (authorization is successful), the port becomes authorized. If authorization fails and a guest VLAN is specified, the switch assigns the port to the guest VLAN. If the switch detects an EAPOL packet while waiting for an Ethernet packet, the switch stops the MAC authentication bypass process and starts 802.1x authentication.

**Figure 129: Message Exchange During MAC Authentication Bypass**

This figure shows the message exchange during MAC authentication bypass.



## Authentication Manager for Port-Based Authentication

### Port-Based Authentication Methods

**Table 150: 802.1x Features**

Authentication method	Mode			
	Single host	Multiple host	MDA	Multiple Authentication
802.1x	VLAN assignment Per-user ACL Filter-ID attribute Downloadable ACL Redirect URL	VLAN assignment	VLAN assignment Per-user ACL Filter-ID attribute Downloadable ACL Redirect URL	VLAN assignment Per-user ACL Filter-ID attribute Downloadable ACL Redirect URL

Authentication method	Mode			
	Single host	Multiple host	MDA	Multiple Authentication
MAC authentication bypass	VLAN assignment Per-user ACL Filter-ID attribute Downloadable ACL Redirect URL	VLAN assignment	VLAN assignment Per-user ACL Filter-Id attribute Downloadable ACL Redirect URL	VLAN assignment Per-user ACL Filter-Id attribute Downloadable ACL Redirect URL
Standalone web authentication	Proxy ACL, Filter-Id attribute, downloadable ACL			
NAC Layer 2 IP validation	Filter-Id attribute Downloadable ACL Redirect URL	Filter-Id attribute Downloadable ACL Redirect URL	Filter-Id attribute Downloadable ACL Redirect URL	Filter-Id attribute Downloadable ACL Redirect URL
Web authentication as fallback method	Proxy ACL Filter-Id attribute Downloadable ACL	Proxy ACL Filter-Id attribute Downloadable ACL	Proxy ACL Filter-Id attribute Downloadable ACL	Proxy ACL Filter-Id attribute Downloadable ACL

<sup>16</sup> Supported in Cisco IOS Release 12.2(50)SE and later.

<sup>17</sup> For clients that do not support 802.1x authentication.

## Per-User ACLs and Filter-Ids



**Note** Using role-based ACLs as Filter-Id is not recommended.

More than one host can be authenticated on MDA-enabled and multiauth ports. The ACL policy applied for one host does not effect the traffic of another host. If only one host is authenticated on a multi-host port, and the other hosts gain network access without authentication, the ACL policy for the first host can be applied to the other connected hosts by specifying any in the source address.

## Port-Based Authentication Manager CLI Commands

The authentication-manager interface-configuration commands control all the authentication methods, such as 802.1x, MAC authentication bypass, and web authentication. The authentication manager commands determine the priority and order of authentication methods applied to a connected host.

The authentication manager commands control generic authentication features, such as host-mode, violation mode, and the authentication timer. Generic authentication commands include the **authentication host-mode**, **authentication violation**, and **authentication timer** interface configuration commands.

802.1x-specific commands begin with the **dot1x** keyword. For example, the **authentication port-control auto** interface configuration command enables authentication on an interface.



To disable dot1x on a switch, remove the configuration globally by using the **no dot1x system-auth-control** command, and also remove it from all configured interfaces.



**Note** If 802.1x authentication is globally disabled, other authentication methods are still enabled on that port, such as web authentication.

To re-enable dot1x on the switch, you must configure both the dot1x global and interface configurations. Incomplete configurations can cause high CPU utilization.

The **authentication manager** commands provide the same functionality as earlier 802.1x commands.

When filtering out verbose system messages generated by the authentication manager, the filtered content typically relates to authentication success. You can also filter verbose messages for 802.1x authentication and MAB authentication. There is a separate command for each authentication method:

- The **no authentication logging verbose** global configuration command filters verbose messages from the authentication manager.
- The **no dot1x logging verbose** global configuration command filters 802.1x authentication verbose messages.
- The **no mab logging verbose** global configuration command filters MAC authentication bypass (MAB) verbose messages

**Table 151: Authentication Manager Commands and Earlier 802.1x Commands**

The authentication manager commands in Cisco IOS Release 12.2(50)SE or later	The equivalent 802.1x commands in Cisco IOS Release 12.2(46)SE and earlier	Description
<b>authentication control-direction</b> {both   in}	<b>dot1x control-direction</b> {both   in}	Enable 802.1x authentication with the wake-on-LAN (WoL) feature, and configure the port control as unidirectional or bidirectional.
<b>authentication event</b>	<b>dot1x auth-fail vlan</b> <b>dot1x critical (interface configuration)</b> <b>dot1x guest-vlan6</b>	Enable the restricted VLAN on a port. Enable the inaccessible-authentication-bypass feature. Specify an active VLAN as an 802.1x guest VLAN.
<b>authentication fallback</b> <i>fallback-profile</i>	<b>dot1x fallback</b> <i>fallback-profile</i>	Configure a port to use web authentication as a fallback method for clients that do not support 802.1x authentication.
<b>authentication host-mode</b> [multi-auth   multi-domain   multi-host   single-host]	<b>dot1x host-mode</b> {single-host   multi-host   multi-domain}	Allow a single host (client) or multiple hosts on an 802.1x-authorized port.

The authentication manager commands in Cisco IOS Release 12.2(50)SE or later	The equivalent 802.1x commands in Cisco IOS Release 12.2(46)SE and earlier	Description
<b>authentication order</b>	<b>mab</b>	Provides the flexibility to define the order of authentication methods to be used.
<b>authentication periodic</b>	<b>dot1x reauthentication</b>	Enable periodic re-authentication of the client.
<b>authentication port-control {auto   force-authorized   force-unauthorized}</b>	<b>dot1x port-control {auto   force-authorized   force-unauthorized}</b>	Enable manual control of the authorization state of the port.
<b>authentication timer</b>	<b>dot1x timeout</b>	Set the 802.1x timers.
<b>authentication violation {protect   restrict   shutdown}</b>	<b>dot1x violation-mode {shutdown   restrict   protect}</b>	Configure the violation modes that occur when a new device connects to a port or when a new device connects to a port after the maximum number of devices are connected to that port.

## Ports in Authorized and Unauthorized States

During 802.1x authentication, depending on the switch port state, the switch can grant a client access to the network. The port starts in the *unauthorized* state. While in this state, the port that is not configured as a voice VLAN port disallows all ingress and egress traffic except for 802.1x authentication, CDP, and STP packets. When a client is successfully authenticated, the port changes to the *authorized* state, allowing all traffic for the client to flow normally. If the port is configured as a voice VLAN port, the port allows VoIP traffic and 802.1x protocol packets before the client is successfully authenticated.



**Note** CDP bypass is not supported and may cause a port to go into err-disabled state.

If a client that does not support 802.1x authentication connects to an unauthorized 802.1x port, the switch requests the client's identity. In this situation, the client does not respond to the request, the port remains in the unauthorized state, and the client is not granted access to the network.

In contrast, when an 802.1x-enabled client connects to a port that is not running the 802.1x standard, the client initiates the authentication process by sending the EAPOL-start frame. When no response is received, the client sends the request for a fixed number of times. Because no response is received, the client begins sending frames as if the port is in the authorized state.

You control the port authorization state by using the **authentication port-control** interface configuration command and these keywords:

- **force-authorized**—disables 802.1x authentication and causes the port to change to the authorized state without any authentication exchange required. The port sends and receives normal traffic without 802.1x-based authentication of the client. This is the default setting.

- **force-unauthorized**—causes the port to remain in the unauthorized state, ignoring all attempts by the client to authenticate. The switch cannot provide authentication services to the client through the port.
- **auto**—enables 802.1x authentication and causes the port to begin in the unauthorized state, allowing only EAPOL frames to be sent and received through the port. The authentication process begins when the link state of the port changes from down to up or when an EAPOL-start frame is received. The switch requests the identity of the client and begins relaying authentication messages between the client and the authentication server. Each client attempting to access the network is uniquely identified by the switch by using the client MAC address.

If the client is successfully authenticated (receives an Accept frame from the authentication server), the port state changes to authorized, and all frames from the authenticated client are allowed through the port. If the authentication fails, the port remains in the unauthorized state, but authentication can be retried. If the authentication server cannot be reached, the switch can resend the request. If no response is received from the server after the specified number of attempts, authentication fails, and network access is not granted.

When a client logs off, it sends an EAPOL-logoff message, causing the switch port to change to the unauthorized state.

If the link state of a port changes from up to down, or if an EAPOL-logoff frame is received, the port returns to the unauthorized state.

## Port-Based Authentication and Switch Stacks

If a switch is added to or removed from a switch stack, 802.1x authentication is not affected as long as the IP connectivity between the RADIUS server and the stack remains intact. This statement also applies if the stack master is removed from the switch stack. Note that if the stack master fails, a stack member becomes the new stack master by using the election process, and the 802.1x authentication process continues as usual.

If IP connectivity to the RADIUS server is interrupted because the switch that was connected to the server is removed or fails, these events occur:

- Ports that are already authenticated and that do not have periodic re-authentication enabled remain in the authenticated state. Communication with the RADIUS server is not required.
- Ports that are already authenticated and that have periodic re-authentication enabled (with the **dot1x re-authentication** global configuration command) fail the authentication process when the re-authentication occurs. Ports return to the unauthenticated state during the re-authentication process. Communication with the RADIUS server is required.

For an ongoing authentication, the authentication fails immediately because there is no server connectivity.

If the switch that failed comes up and rejoins the switch stack, the authentications might or might not fail depending on the boot-up time and whether the connectivity to the RADIUS server is re-established by the time the authentication is attempted.

To avoid loss of connectivity to the RADIUS server, you should ensure that there is a redundant connection to it. For example, you can have a redundant connection to the stack master and another to a stack member, and if the stack master fails, the switch stack still has connectivity to the RADIUS server.

## 802.1x Host Mode

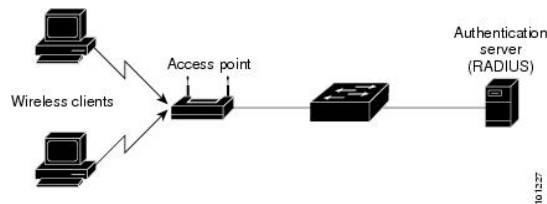
You can configure an 802.1x port for single-host or for multiple-hosts mode. In single-host mode, only one client can be connected to the 802.1x-enabled switch port. The switch detects the client by sending an EAPOL

frame when the port link state changes to the up state. If a client leaves or is replaced with another client, the switch changes the port link state to down, and the port returns to the unauthorized state.

In multiple-hosts mode, you can attach multiple hosts to a single 802.1x-enabled port. In this mode, only one of the attached clients must be authorized for all clients to be granted network access. If the port becomes unauthorized (re-authentication fails or an EAPOL-logoff message is received), the switch denies network access to all of the attached clients.

In this topology, the wireless access point is responsible for authenticating the clients attached to it, and it also acts as a client to the switch.

**Figure 130: Multiple Host Mode Example**



**Note** For all host modes, the line protocol stays up before authorization when port-based authentication is configured.

The switch supports multidomain authentication (MDA), which allows both a data device and a voice device, such as an IP Phone (Cisco or non-Cisco), to connect to the same switch port.

## 802.1x Multiple Authentication Mode

Multiple-authentication (multiauth) mode allows multiple authenticated clients on the data VLAN and voice VLAN. Each host is individually authenticated. There is no limit to the number of data or voice device that can be authenticated on a multiauthport.

If a hub or access point is connected to an 802.1x-enabled port, each connected client must be authenticated. For non-802.1x devices, you can use MAC authentication bypass or web authentication as the per-host authentication fallback method to authenticate different hosts with different methods on a single port.



**Note** When a port is in multiple-authentication mode, the authentication-failed VLAN features do not activate.

You can assign a RADIUS-server-supplied VLAN in multi-auth mode, under the following conditions:

- The host is the first host authorized on the port, and the RADIUS server supplies VLAN information
- Subsequent hosts are authorized with a VLAN that matches the operational VLAN.
- A host is authorized on the port with no VLAN assignment, and subsequent hosts either have no VLAN assignment, or their VLAN information matches the operational VLAN.
- The first host authorized on the port has a group VLAN assignment, and subsequent hosts either have no VLAN assignment, or their group VLAN matches the group VLAN on the port. Subsequent hosts must use the same VLAN from the VLAN group as the first host. If a VLAN list is used, all hosts are subject to the conditions specified in the VLAN list.

- After a VLAN is assigned to a host on the port, subsequent hosts must have matching VLAN information or be denied access to the port.
- You cannot configure a guest VLAN or an auth-fail VLAN in multi-auth mode.
- The behavior of the critical-auth VLAN is not changed for multi-auth mode. When a host tries to authenticate and the server is not reachable, all authorized hosts are reinitialized in the configured VLAN.

## Multi-auth Per User VLAN assignment

The Multi-auth Per User VLAN assignment feature allows you to create multiple operational access VLANs based on VLANs assigned to the clients on the port that has a single configured access VLAN. The port configured as an access port where the traffic for all the VLANs associated with data domain is not dot1q tagged, and these VLANs are treated as native VLANs.

The number of hosts per multi-auth port is 8, however there can be more hosts.

The following scenarios are associated with the multi-auth Per User VLAN assignments:

### Scenario one

When a hub is connected to an access port, and the port is configured with an access VLAN (V0).

The host (H1) is assigned to VLAN (V1) through the hub. The operational VLAN of the port is changed to V1. This behaviour is similar on a single-host or multi-domain-auth port.

When a second host (H2) is connected and gets assigned to VLAN (V2), the port will have two operational VLANs (V1 and V2). If H1 and H2 sends untagged ingress traffic, H1 traffic is mapped to VLAN (V1) and H2 traffic to VLAN (V2), all egress traffic going out of the port on VLAN (V1) and VLAN (V2) are untagged.

If both the hosts, H1 and H2 are logged out or the sessions are removed due to some reason then VLAN (V1) and VLAN (V2) are removed from the port, and the configured VLAN (V0) is restored on the port.

### Scenario two

When a hub is connected to an access port, and the port is configured with an access VLAN (V0). The host (H1) is assigned to VLAN (V1) through the hub. The operational VLAN of the port is changed to V1.

When a second host (H2) is connected and gets authorized without explicit vlan policy, H2 is expected to use the configured VLAN (V0) that is restored on the port. All egress traffic going out of two operational VLANs, VLAN (V0) and VLAN (V1) are untagged.

If host (H2) is logged out or the session is removed due to some reason then the configured VLAN (V0) is removed from the port, and VLAN (V1) becomes the only operational VLAN on the port.

### Scenario three

When a hub is connected to an access port in open mode, and the port is configured with an access VLAN (V0).

The host (H1) is assigned to VLAN (V1) through the hub. The operational VLAN of the port is changed to V1. When a second host (H2) is connected and remains unauthorized, it still has access to operational VLAN (V1) due to open mode.

If host H1 is logged out or the session is removed due to some reason, VLAN (V1) is removed from the port and host (H2) gets assigned to VLAN (V0).




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**Note** The combination of Open mode and VLAN assignment has an adverse affect on host (H2) because it has an IP address in the subnet that corresponds to VLAN (V1).

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### Limitation in Multi-auth Per User VLAN assignment

In the Multi-auth Per User VLAN assignment feature, egress traffic from multiple vlans are untagged on a port where the hosts receive traffic that is not meant for them. This can be a problem with broadcast and multicast traffic.

- **IPv4 ARPs:** Hosts receive ARP packets from other subnets. This is a problem if two subnets in different Virtual Routing and Forwarding (VRF) tables with overlapping IP address range are active on the port. The host ARP cache may get invalid entries.

- **IPv6 control packets:** In IPv6 deployments, Router Advertisements (RA) are processed by hosts that are not supposed to receive them. When a host from one VLAN receives RA from a different VLAN, the host assign incorrect IPv6 address to itself. Such a host is unable to get access to the network.

The workaround is to enable the IPv6 first hop security so that the broadcast ICMPv6 packets are converted to unicast and sent out from multi-auth enabled ports.. The packet is replicated for each client in multi-auth port belonging to the VLAN and the destination MAC is set to an individual client. Ports having one VLAN, ICMPv6 packets broadcast normally.

- **IP multicast:** Multicast traffic destined to a multicast group gets replicated for different VLANs if the hosts on those VLANs join the multicast group. When two hosts in different VLANs join a multicast group (on the same mutli-auth port), two copies of each multicast packet are sent out from that port.

## MAC Move

When a MAC address is authenticated on one switch port, that address is not allowed on another authentication manager-enabled port of the switch. If the switch detects that same MAC address on another authentication manager-enabled port, the address is not allowed.

There are situations where a MAC address might need to move from one port to another on the same switch. For example, when there is another device (for example a hub or an IP phone) between an authenticated host and a switch port, you might want to disconnect the host from the device and connect it directly to another port on the same switch.

You can globally enable MAC move so the device is reauthenticated on the new port. When a host moves to a second port, the session on the first port is deleted, and the host is reauthenticated on the new port. MAC move is supported on all host modes. (The authenticated host can move to any port on the switch, no matter which host mode is enabled on the that port.) When a MAC address moves from one port to another, the switch terminates the authenticated session on the original port and initiates a new authentication sequence on the new port. The MAC move feature applies to both voice and data hosts.




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**Note** In open authentication mode, a MAC address is immediately moved from the original port to the new port, with no requirement for authorization on the new port.

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## MAC Replace

The MAC replace feature can be configured to address the violation that occurs when a host attempts to connect to a port where another host was previously authenticated.



**Note** This feature does not apply to ports in multi-auth mode, because violations are not triggered in that mode. It does not apply to ports in multiple host mode, because in that mode, only the first host requires authentication.

If you configure the **authentication violation** interface configuration command with the **replace** keyword, the authentication process on a port in multi-domain mode is:

- A new MAC address is received on a port with an existing authenticated MAC address.
- The authentication manager replaces the MAC address of the current data host on the port with the new MAC address.
- The authentication manager initiates the authentication process for the new MAC address.
- If the authentication manager determines that the new host is a voice host, the original voice host is removed.

If a port is in open authentication mode, any new MAC address is immediately added to the MAC address table.

## 802.1x Accounting

The 802.1x standard defines how users are authorized and authenticated for network access but does not keep track of network usage. 802.1x accounting is disabled by default. You can enable 802.1x accounting to monitor this activity on 802.1x-enabled ports:

- User successfully authenticates.
- User logs off.
- Link-down occurs.
- Re-authentication successfully occurs.
- Re-authentication fails.

The switch does not log 802.1x accounting information. Instead, it sends this information to the RADIUS server, which must be configured to log accounting messages.

## 802.1x Accounting Attribute-Value Pairs

The information sent to the RADIUS server is represented in the form of Attribute-Value (AV) pairs. These AV pairs provide data for different applications. (For example, a billing application might require information that is in the Acct-Input-Octets or the Acct-Output-Octets attributes of a RADIUS packet.)

AV pairs are automatically sent by a switch that is configured for 802.1x accounting. Three types of RADIUS accounting packets are sent by a switch:

- START—sent when a new user session starts

- INTERIM—sent during an existing session for updates
- STOP—sent when a session terminates



**Note** To view debug logs for RADIUS and AAA, use the **show platform software trace message smd** command. For more information, see the Tracing Commands section in *Command Reference Guide, Cisco IOS XE Denali 16.1.1*.

This table lists the AV pairs and when they are sent are sent by the switch.

**Table 152: Accounting AV Pairs**

Attribute Number	AV Pair Name	START	INTERIM	STOP
Attribute[1]	User-Name	Always	Always	Always
Attribute[4]	NAS-IP-Address	Always	Always	Always
Attribute[5]	NAS-Port	Always	Always	Always
Attribute[8]	Framed-IP-Address	Never	Sometimes <sup>18</sup>	Sometimes
Attribute[30]	Called-Station-ID	Always	Always	Always
Attribute[31]	Calling-Station-ID	Always	Always	Always
Attribute[40]	Acct-Status-Type	Always	Always	Always
Attribute[41]	Acct-Delay-Time	Always	Always	Always
Attribute[42]	Acct-Input-Octets	Never	Always	Always
Attribute[43]	Acct-Output-Octets	Never	Always	Always
Attribute[47]	Acct-Input-Packets	Never	Always	Always
Attribute[48]	Acct-Output-Packets	Never	Always	Always
Attribute[44]	Acct-Session-ID	Always	Always	Always
Attribute[45]	Acct-Authentic	Always	Always	Always
Attribute[46]	Acct-Session-Time	Never	Always	Always
Attribute[49]	Acct-Terminate-Cause	Never	Never	Always
Attribute[61]	NAS-Port-Type	Always	Always	Always

<sup>18</sup> The Framed-IP-Address AV pair is sent when a valid static IP address is configured or w when a Dynamic Host Control Protocol (DHCP) binding exists for the host in the DHCP snooping bindings table.



## 802.1x Readiness Check

The 802.1x readiness check monitors 802.1x activity on all the switch ports and displays information about the devices connected to the ports that support 802.1x. You can use this feature to determine if the devices connected to the switch ports are 802.1x-capable. You use an alternate authentication such as MAC authentication bypass or web authentication for the devices that do not support 802.1x functionality.

This feature only works if the supplicant on the client supports a query with the NOTIFY EAP notification packet. The client must respond within the 802.1x timeout value.

### Related Topics

[Configuring 802.1x Readiness Check](#), on page 2032

## Switch-to-RADIUS-Server Communication

RADIUS security servers are identified by their hostname or IP address, hostname and specific UDP port numbers, or IP address and specific UDP port numbers. The combination of the IP address and UDP port number creates a unique identifier, which enables RADIUS requests to be sent to multiple UDP ports on a server at the same IP address. If two different host entries on the same RADIUS server are configured for the same service—for example, authentication—the second host entry configured acts as the fail-over backup to the first one. The RADIUS host entries are tried in the order that they were configured.

### Related Topics

[Configuring the Switch-to-RADIUS-Server Communication](#)

## 802.1x Authentication with VLAN Assignment

The switch supports 802.1x authentication with VLAN assignment. After successful 802.1x authentication of a port, the RADIUS server sends the VLAN assignment to configure the switch port. The RADIUS server database maintains the username-to-VLAN mappings, assigning the VLAN based on the username of the client connected to the switch port. You can use this feature to limit network access for certain users.

Voice device authentication is supported with multidomain host mode in Cisco IOS Release 12.2(37)SE. In Cisco IOS Release 12.2(40)SE and later, when a voice device is authorized and the RADIUS server returned an authorized VLAN, the voice VLAN on the port is configured to send and receive packets on the assigned voice VLAN. Voice VLAN assignment behaves the same as data VLAN assignment on multidomain authentication (MDA)-enabled ports.

When configured on the switch and the RADIUS server, 802.1x authentication with VLAN assignment has these characteristics:

- If no VLAN is supplied by the RADIUS server or if 802.1x authentication is disabled, the port is configured in its access VLAN after successful authentication. Recall that an access VLAN is a VLAN assigned to an access port. All packets sent from or received on this port belong to this VLAN.
- If 802.1x authentication is enabled but the VLAN information from the RADIUS server is not valid, authorization fails and configured VLAN remains in use. This prevents ports from appearing unexpectedly in an inappropriate VLAN because of a configuration error.

Configuration errors could include specifying a VLAN for a routed port, a malformed VLAN ID, a nonexistent or internal (routed port) VLAN ID, an RSPAN VLAN, a shut down or suspended VLAN. In the case of a multidomain host port, configuration errors can also be due to an attempted assignment of a data VLAN that matches the configured or assigned voice VLAN ID (or the reverse).

- If 802.1x authentication is enabled and all information from the RADIUS server is valid, the authorized device is placed in the specified VLAN after authentication.
- If the multiple-hosts mode is enabled on an 802.1x port, all hosts are placed in the same VLAN (specified by the RADIUS server) as the first authenticated host.
- Enabling port security does not impact the RADIUS server-assigned VLAN behavior.
- If 802.1x authentication is disabled on the port, it is returned to the configured access VLAN and configured voice VLAN.
- If an 802.1x port is authenticated and put in the RADIUS server-assigned VLAN, any change to the port access VLAN configuration does not take effect. In the case of a multidomain host, the same applies to voice devices when the port is fully authorized with these exceptions:
  - If the VLAN configuration change of one device results in matching the other device configured or assigned VLAN, then authorization of all devices on the port is terminated and multidomain host mode is disabled until a valid configuration is restored where data and voice device configured VLANs no longer match.
  - If a voice device is authorized and is using a downloaded voice VLAN, the removal of the voice VLAN configuration, or modifying the configuration value to *dot1p* or *untagged* results in voice device un-authorization and the disablement of multi-domain host mode.

When the port is in the force authorized, force unauthorized, unauthorized, or shutdown state, it is put into the configured access VLAN.

If an 802.1x port is authenticated and put in the RADIUS server-assigned VLAN, any change to the port access VLAN configuration does not take effect. In the case of a multidomain host, the same applies to voice devices when the port is fully authorized with these exceptions:

- If the VLAN configuration change of one device results in matching the other device configured or assigned VLAN, authorization of all devices on the port is terminated and multidomain host mode is disabled until a valid configuration is restored where data and voice device configured VLANs no longer match.
- If a voice device is authorized and is using a downloaded voice VLAN, the removal of the voice VLAN configuration, or modifying the configuration value to *dot1p* or *untagged* results in voice device un-authorization and the disablement of multi-domain host mode.

When the port is in the force authorized, force unauthorized, unauthorized, or shutdown state, it is put into the configured access VLAN.

To configure VLAN assignment you need to perform these tasks:

- Enable AAA authorization by using the **network** keyword to allow interface configuration from the RADIUS server.
- Enable 802.1x authentication. (The VLAN assignment feature is automatically enabled when you configure 802.1x authentication on an access port).
- Assign vendor-specific tunnel attributes in the RADIUS server. The RADIUS server must return these attributes to the switch:
  - [64] Tunnel-Type = VLAN
  - [65] Tunnel-Medium-Type = 802

- [81] Tunnel-Private-Group-ID = VLAN name or VLAN ID
- [83] Tunnel-Preference

Attribute [64] must contain the value *VLAN* (type 13). Attribute [65] must contain the value *802* (type 6). Attribute [81] specifies the *VLAN name* or *VLAN ID* assigned to the IEEE 802.1x-authenticated user.

## 802.1x Authentication with Per-User ACLs

You can enable per-user access control lists (ACLs) to provide different levels of network access and service to an 802.1x-authenticated user. When the RADIUS server authenticates a user connected to an 802.1x port, it retrieves the ACL attributes based on the user identity and sends them to the switch. The switch applies the attributes to the 802.1x port for the duration of the user session. The switch removes the per-user ACL configuration when the session is over, if authentication fails, or if a link-down condition occurs. The switch does not save RADIUS-specified ACLs in the running configuration. When the port is unauthorized, the switch removes the ACL from the port.

You can configure router ACLs and input port ACLs on the same switch. However, a port ACL takes precedence over a router ACL. If you apply input port ACL to an interface that belongs to a VLAN, the port ACL takes precedence over an input router ACL applied to the VLAN interface. Incoming packets received on the port, to which a port ACL is applied, are filtered by the port ACL. Incoming routed packets received on other ports are filtered by the router ACL. Outgoing routed packets are filtered by the router ACL. To avoid configuration conflicts, you should carefully plan the user profiles stored on the RADIUS server.

RADIUS supports per-user attributes, including vendor-specific attributes. These vendor-specific attributes (VSAs) are in octet-string format and are passed to the switch during the authentication process. The VSAs used for per-user ACLs are `inac1#<n>` for the ingress direction and `outac1#<n>` for the egress direction. MAC ACLs are supported only in the ingress direction. The switch supports VSAs only in the ingress direction. It does not support port ACLs in the egress direction on Layer 2 ports.

Use only the extended ACL syntax style to define the per-user configuration stored on the RADIUS server. When the definitions are passed from the RADIUS server, they are created by using the extended naming convention. However, if you use the Filter-Id attribute, it can point to a standard ACL.

You can use the Filter-Id attribute to specify an inbound or outbound ACL that is already configured on the switch. The attribute contains the ACL number followed by `.in` for ingress filtering or `.out` for egress filtering. If the RADIUS server does not allow the `.in` or `.out` syntax, the access list is applied to the outbound ACL by default. The user is marked unauthorized if the Filter-Id sent from the RADIUS server is not configured on the device. Because of limited support of Cisco IOS access lists on the switch, the Filter-Id attribute is supported only for IP ACLs numbered in the range of 1 to 199 (IP standard ACLs) and 1300 to 2699 (IP extended ACLs).

The maximum size of the per-user ACL is 4000 ASCII characters but is limited by the maximum size of RADIUS-server per-user ACLs.

You must meet the following prerequisites to configure per-user ACLs:

- Enable AAA authentication.
- Enable AAA authorization by using the **network** keyword to allow interface configuration from the RADIUS server.
- Enable 802.1x authentication.
- Configure the user profile and VSAs on the RADIUS server.
- Configure the 802.1x port for single-host mode.



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**Note** Per-user ACLs are supported only in single-host mode.

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## 802.1x Authentication with Downloadable ACLs and Redirect URLs

You can download ACLs and redirect URLs from a RADIUS server to the switch during 802.1x authentication or MAC authentication bypass of the host. You can also download ACLs during web authentication.



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**Note** A downloadable ACL is also referred to as a *dACL*.

---

If more than one host is authenticated and the host is in single-host, MDA, or multiple-authentication mode, the switch changes the source address of the ACL to the host IP address.

You can apply the ACLs and redirect URLs to all the devices connected to the 802.1x-enabled port.

If no ACLs are downloaded during 802.1x authentication, the switch applies the static default ACL on the port to the host. On a voice VLAN port configured in multi-auth or MDA mode, the switch applies the ACL only to the phone as part of the authorization policies.



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**Note** The limit for dACL with stacking is 64 ACEs per dACL per port. The limit without stacking is the number of available TCAM entries which varies based on the other ACL features that are active.

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## Cisco Secure ACS and Attribute-Value Pairs for the Redirect URL

The switch uses these *cisco-av-pair* VSAs:

- url-redirect is the HTTP or HTTPS URL.
- url-redirect-acl is the switch ACL name or number.

The switch uses the CiscoSecure-defined-ACL attribute value pair to intercept an HTTP or HTTPS request from the end point. The switch then forwards the client web browser to the specified redirect address. The url-redirect AV pair on the Cisco Secure ACS contains the URL to which the web browser is redirected. The url-redirect-acl attribute value pair contains the name or number of an ACL that specifies the HTTP or HTTPS traffic to redirect.



- 
- Note**
- Traffic that matches a permit ACE in the ACL is redirected.
  - An ACE that matches permit rule of the url-redirect-acl gets the client redirected to url-redirect page. The client traffic is allowed when a deny rule is matched.
  - Define the URL redirect ACL and the default port ACL on the switch.
- 

If a redirect URL is configured for a client on the authentication server, a default port ACL on the connected client switch port must also be configured.

When security ACL/dACL and punt/redirect ACLs are applied together to the session, the url-redirect-acl has the higher priority.

For more information about using redirect ACLs, refer the document [here](#).

## Cisco Secure ACS and Attribute-Value Pairs for Downloadable ACLs

You can set the CiscoSecure-Defined-ACL Attribute-Value (AV) pair on the Cisco Secure ACS with the RADIUS cisco-av-pair vendor-specific attributes (VSAs). This pair specifies the names of the downloadable ACLs on the Cisco Secure ACS with the #ACL#-IP-name-number attribute.

- The *name* is the ACL name.
- The *number* is the version number (for example, 3f783768).

If a downloadable ACL is configured for a client on the authentication server, a default port ACL on the connected client switch port must also be configured.

If the default ACL is configured on the switch and the Cisco Secure ACS sends a host-access-policy to the switch, it applies the policy to traffic from the host connected to a switch port. If the policy does not apply, the switch applies the default ACL. If the Cisco Secure ACS sends the switch a downloadable ACL, this ACL takes precedence over the default ACL that is configured on the switch port. However, if the switch receives an host access policy from the Cisco Secure ACS but the default ACL is not configured, the authorization failure is declared.

## VLAN ID-Based MAC Authentication

You can use VLAN ID-based MAC authentication if you wish to authenticate hosts based on a static VLAN ID instead of a downloadable VLAN. When you have a static VLAN policy configured on your switch, VLAN information is sent to an IAS (Microsoft) RADIUS server along with the MAC address of each host for authentication. The VLAN ID configured on the connected port is used for MAC authentication. By using VLAN ID-based MAC authentication with an IAS server, you can have a fixed number of VLANs in the network.

The feature also limits the number of VLANs monitored and handled by STP. The network can be managed as a fixed VLAN.

## 802.1x Authentication with Guest VLAN

You can configure a guest VLAN for each 802.1x port on the switch to provide limited services to clients, such as downloading the 802.1x client. These clients might be upgrading their system for 802.1x authentication, and some hosts, such as Windows 98 systems, might not be IEEE 802.1x-capable.

When you enable a guest VLAN on an 802.1x port, the switch assigns clients to a guest VLAN when the switch does not receive a response to its EAP request/identity frame or when EAPOL packets are not sent by the client.

The switch maintains the EAPOL packet history. If an EAPOL packet is detected on the interface during the lifetime of the link, the switch determines that the device connected to that interface is an IEEE 802.1x-capable supplicant, and the interface does not change to the guest VLAN state. EAPOL history is cleared if the interface link status goes down. If no EAPOL packet is detected on the interface, the interface changes to the guest VLAN state.

If the switch is trying to authorize an 802.1x-capable voice device and the AAA server is unavailable, the authorization attempt fails, but the detection of the EAPOL packet is saved in the EAPOL history. When the AAA server becomes available, the switch authorizes the voice device. However, the switch no longer allows other devices access to the guest VLAN. To prevent this situation, use one of these command sequences:

- Enter the **authentication event no-response action authorize vlan** *vlan-id* interface configuration command to allow access to the guest VLAN.
- Enter the **shutdown** interface configuration command followed by the **no shutdown** interface configuration command to restart the port.

If devices send EAPOL packets to the switch during the lifetime of the link, the switch no longer allows clients that fail authentication access to the guest VLAN.

**Note**

If an EAPOL packet is detected after the interface has changed to the guest VLAN, the interface reverts to an unauthorized state, and 802.1x authentication restarts.

Any number of 802.1x-incapable clients are allowed access when the switch port is moved to the guest VLAN. If an 802.1x-capable client joins the same port on which the guest VLAN is configured, the port is put into the unauthorized state in the user-configured access VLAN, and authentication is restarted.

Guest VLANs are supported on 802.1x ports in single host, multiple host, multi-auth and multi-domain modes.

You can configure any active VLAN except an RSPAN VLAN, a private VLAN, or a voice VLAN as an 802.1x guest VLAN. The guest VLAN feature is not supported on internal VLANs (routed ports) or trunk ports; it is supported only on access ports.

The switch supports *MAC authentication bypass*. When MAC authentication bypass is enabled on an 802.1x port, the switch can authorize clients based on the client MAC address when IEEE 802.1x authentication times out while waiting for an EAPOL message exchange. After detecting a client on an 802.1x port, the switch waits for an Ethernet packet from the client. The switch sends the authentication server a RADIUS-access/request frame with a username and password based on the MAC address. If authorization succeeds, the switch grants the client access to the network. If authorization fails, the switch assigns the port to the guest VLAN if one is specified.

## 802.1x Authentication with Restricted VLAN

You can configure a restricted VLAN (also referred to as an *authentication failed VLAN*) for each IEEE 802.1x port on a switch stack or a switch to provide limited services to clients that cannot access the guest VLAN. These clients are 802.1x-compliant and cannot access another VLAN because they fail the authentication process. A restricted VLAN allows users without valid credentials in an authentication server (typically, visitors to an enterprise) to access a limited set of services. The administrator can control the services available to the restricted VLAN.

**Note**

You can configure a VLAN to be both the guest VLAN and the restricted VLAN if you want to provide the same services to both types of users.

Without this feature, the client attempts and fails authentication indefinitely, and the switch port remains in the spanning-tree blocking state. With this feature, you can configure the switch port to be in the restricted VLAN after a specified number of authentication attempts (the default value is 3 attempts).

The authenticator counts the failed authentication attempts for the client. When this count exceeds the configured maximum number of authentication attempts, the port moves to the restricted VLAN. The failed attempt count increments when the RADIUS server replies with either an *EAP failure* or an empty response without an EAP packet. When the port moves into the restricted VLAN, the failed attempt counter resets.

Users who fail authentication remain in the restricted VLAN until the next re-authentication attempt. A port in the restricted VLAN tries to re-authenticate at configured intervals (the default is 60 seconds). If re-authentication fails, the port remains in the restricted VLAN. If re-authentication is successful, the port moves either to the configured VLAN or to a VLAN sent by the RADIUS server. You can disable re-authentication. If you do this, the only way to restart the authentication process is for the port to receive a *link down* or *EAP logoff* event. We recommend that you keep re-authentication enabled if a client might connect through a hub. When a client disconnects from the hub, the port might not receive the *link down* or *EAP logoff* event.

After a port moves to the restricted VLAN, a simulated EAP success message is sent to the client. This prevents clients from indefinitely attempting authentication. Some clients (for example, devices running Windows XP) cannot implement DHCP without EAP success.

Restricted VLANs are supported on 802.1x ports in all host modes and on Layer 2 ports.

You can configure any active VLAN except an RSPAN VLAN, a primary private VLAN, or a voice VLAN as an 802.1x restricted VLAN. The restricted VLAN feature is not supported on internal VLANs (routed ports) or trunk ports; it is supported only on access ports.

Other security port features such as dynamic ARP Inspection, DHCP snooping, and IP source guard can be configured independently on a restricted VLAN.

## 802.1x Authentication with Inaccessible Authentication Bypass

Use the inaccessible authentication bypass feature, also referred to as *critical authentication* or the *AAA fail policy*, when the switch cannot reach the configured RADIUS servers and new hosts cannot be authenticated. You can configure the switch to connect those hosts to *critical ports*.

When a new host tries to connect to the critical port, that host is moved to a user-specified access VLAN, the *critical VLAN*. The administrator gives limited authentication to the hosts.

When the switch tries to authenticate a host connected to a critical port, the switch checks the status of the configured RADIUS server. If a server is available, the switch can authenticate the host. However, if all the RADIUS servers are unavailable, the switch grants network access to the host and puts the port in the *critical-authentication* state, which is a special case of the authentication state.



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**Note**

If *critical authentication* is configured on interface, then vlan used for critical authorization (*critical vlan*) should be active on the switch. If the *critical vlan* is inactive (or) down, *critical authentication* session will keep trying to enable inactive vlan and fail repeatedly. This can lead to large amount of memory holding.

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## Inaccessible Authentication Bypass Support on Multiple-Authentication Ports

When a port is configured on any host mode and the AAA server is unavailable, the port is then configured to multi-host mode and moved to the critical VLAN. To support this inaccessible bypass on multiple-authentication (multiauth) ports, use the **authentication event server dead action reinitialize vlan *vlan-id*** command. When a new host tries to connect to the critical port, that port is reinitialized and all the connected hosts are moved to the user-specified access VLAN.

This command is supported on all host modes.

## Inaccessible Authentication Bypass Authentication Results

The behavior of the inaccessible authentication bypass feature depends on the authorization state of the port:

- If the port is unauthorized when a host connected to a critical port tries to authenticate and all servers are unavailable, the switch puts the port in the critical-authentication state in the RADIUS-configured or user-specified access VLAN.
- If the port is already authorized and reauthentication occurs, the switch puts the critical port in the critical-authentication state in the current VLAN, which might be the one previously assigned by the RADIUS server.
- If the RADIUS server becomes unavailable during an authentication exchange, the current exchange times out, and the switch puts the critical port in the critical-authentication state during the next authentication attempt.

You can configure the critical port to reinitialize hosts and move them out of the critical VLAN when the RADIUS server is again available. When this is configured, all critical ports in the critical-authentication state are automatically re-authenticated.

## Inaccessible Authentication Bypass Feature Interactions

Inaccessible authentication bypass interacts with these features:

- Guest VLAN—Inaccessible authentication bypass is compatible with guest VLAN. When a guest VLAN is enabled on 8021.x port, the features interact as follows:
  - If at least one RADIUS server is available, the switch assigns a client to a guest VLAN when the switch does not receive a response to its EAP request/identity frame or when EAPOL packets are not sent by the client.
  - If all the RADIUS servers are not available and the client is connected to a critical port, the switch authenticates the client and puts the critical port in the critical-authentication state in the RADIUS-configured or user-specified access VLAN.
  - If all the RADIUS servers are not available and the client is not connected to a critical port, the switch might not assign clients to the guest VLAN if one is configured.
  - If all the RADIUS servers are not available and if a client is connected to a critical port and was previously assigned to a guest VLAN, the switch keeps the port in the guest VLAN.
- Restricted VLAN—If the port is already authorized in a restricted VLAN and the RADIUS servers are unavailable, the switch puts the critical port in the critical-authentication state in the restricted VLAN.
- 802.1x accounting—Accounting is not affected if the RADIUS servers are unavailable.



- Private VLAN—You can configure inaccessible authentication bypass on a private VLAN host port. The access VLAN must be a secondary private VLAN.
- Voice VLAN—Inaccessible authentication bypass is compatible with voice VLAN, but the RADIUS-configured or user-specified access VLAN and the voice VLAN must be different.
- Remote Switched Port Analyzer (RSPAN)—Do not configure an RSPAN VLAN as the RADIUS-configured or user-specified access VLAN for inaccessible authentication bypass.

In a switch stack:

- The stack master checks the status of the RADIUS servers by sending keepalive packets. When the status of a RADIUS server changes, the stack master sends the information to the stack members. The stack members can then check the status of RADIUS servers when re-authenticating critical ports.
- If the new stack master is elected, the link between the switch stack and RADIUS server might change, and the new stack immediately sends keepalive packets to update the status of the RADIUS servers. If the server status changes from *dead* to *alive*, the switch re-authenticates all switch ports in the critical-authentication state.

When a member is added to the stack, the stack master sends the member the server status.

## 802.1x Critical Voice VLAN

When an IP phone connected to a port is authenticated by the Cisco Identity Services Engine (ISE), the phone is put into the voice domain. If the ISE is not reachable, the switch cannot determine if the device is a voice device. If the server is unavailable, the phone cannot access the voice network and therefore cannot operate.

For data traffic, you can configure inaccessible authentication bypass, or critical authentication, to allow traffic to pass through on the native VLAN when the server is not available. If the RADIUS authentication server is unavailable (down) and inaccessible authentication bypass is enabled, the switch grants the client access to the network and puts the port in the critical-authentication state in the RADIUS-configured or the user-specified access VLAN. When the switch cannot reach the configured RADIUS servers and new hosts cannot be authenticated, the switch connects those hosts to critical ports. A new host trying to connect to the critical port is moved to a user-specified access VLAN, the critical VLAN, and granted limited authentication.



**Note** Dynamic assignment of critical voice VLAN is not supported with nested service templates. It causes the device to switch between VLANs continuously in a loop.

You can enter the **authentication event server dead action authorize voice** interface configuration command to configure the critical voice VLAN feature. When the ISE does not respond, the port goes into critical authentication mode. When traffic coming from the host is tagged with the voice VLAN, the connected device (the phone) is put in the configured voice VLAN for the port. The IP phones learn the voice VLAN identification through Cisco Discovery Protocol (Cisco devices) or through LLDP or DHCP.

You can configure the voice VLAN for a port by entering the **switchport voice vlan *vlan-id*** interface configuration command.

This feature is supported in multidomain and multi-auth host modes. Although you can enter the command when the switch in single-host or multi-host mode, the command has no effect unless the device changes to multidomain or multi-auth host mode.

## 802.1x User Distribution

You can configure 802.1x user distribution to load-balance users with the same group name across multiple different VLANs.

The VLANs are either supplied by the RADIUS server or configured through the switch CLI under a VLAN group name.

- Configure the RADIUS server to send more than one VLAN name for a user. The multiple VLAN names can be sent as part of the response to the user. The 802.1x user distribution tracks all the users in a particular VLAN and achieves load balancing by moving the authorized user to the least populated VLAN.
- Configure the RADIUS server to send a VLAN group name for a user. The VLAN group name can be sent as part of the response to the user. You can search for the selected VLAN group name among the VLAN group names that you configured by using the switch CLI. If the VLAN group name is found, the corresponding VLANs under this VLAN group name are searched to find the least populated VLAN. Load balancing is achieved by moving the corresponding authorized user to that VLAN.



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**Note** The RADIUS server can send the VLAN information in any combination of VLAN-IDs, VLAN names, or VLAN groups.

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### 802.1x User Distribution Configuration Guidelines

- Confirm that at least one VLAN is mapped to the VLAN group.
- You can map more than one VLAN to a VLAN group.
- You can modify the VLAN group by adding or deleting a VLAN.
- When you clear an existing VLAN from the VLAN group name, none of the authenticated ports in the VLAN are cleared, but the mappings are removed from the existing VLAN group.
- If you clear the last VLAN from the VLAN group name, the VLAN group is cleared.
- You can clear a VLAN group even when the active VLANs are mapped to the group. When you clear a VLAN group, none of the ports or users that are in the authenticated state in any VLAN within the group are cleared, but the VLAN mappings to the VLAN group are cleared.

## IEEE 802.1x Authentication with Voice VLAN Ports

A voice VLAN port is a special access port associated with two VLAN identifiers:

- VVID to carry voice traffic to and from the IP phone. The VVID is used to configure the IP phone connected to the port.
- PVID to carry the data traffic to and from the workstation connected to the switch through the IP phone. The PVID is the native VLAN of the port.

The IP phone uses the VVID for its voice traffic, regardless of the authorization state of the port. This allows the phone to work independently of IEEE 802.1x authentication.

In single-host mode, only the IP phone is allowed on the voice VLAN. In multiple-hosts mode, additional clients can send traffic on the voice VLAN after a supplicant is authenticated on the PVID. When multiple-hosts mode is enabled, the supplicant authentication affects both the PVID and the VVID.

A voice VLAN port becomes active when there is a link, and the device MAC address appears after the first CDP message from the IP phone. Cisco IP phones do not relay CDP messages from other devices. As a result, if several IP phones are connected in series, the switch recognizes only the one directly connected to it. When IEEE 802.1x authentication is enabled on a voice VLAN port, the switch drops packets from unrecognized IP phones more than one hop away.

When IEEE 802.1x authentication is enabled on a switch port, you can configure an access port VLAN that is also a voice VLAN.

When IP phones are connected to an 802.1x-enabled switch port that is in single host mode, the switch grants the phones network access without authenticating them. We recommend that you use multidomain authentication (MDA) on the port to authenticate both a data device and a voice device, such as an IP phone



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**Note** If you enable IEEE 802.1x authentication on an access port on which a voice VLAN is configured and to which a Cisco IP Phone is connected, the Cisco IP phone loses connectivity to the switch for up to 30 seconds.

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## IEEE 802.1x Authentication with Port Security

In general, Cisco does not recommend enabling port security when IEEE 802.1x is enabled. Since IEEE 802.1x enforces a single MAC address per port (or per VLAN when MDA is configured for IP telephony), port security is redundant and in some cases may interfere with expected IEEE 802.1x operations.

## IEEE 802.1x Authentication with Wake-on-LAN

The IEEE 802.1x authentication with wake-on-LAN (WoL) feature allows dormant PCs to be powered when the switch receives a specific Ethernet frame, known as the *magic packet*. You can use this feature in environments where administrators need to connect to systems that have been powered down.

When a host that uses WoL is attached through an IEEE 802.1x port and the host powers off, the IEEE 802.1x port becomes unauthorized. The port can only receive and send EAPOL packets, and WoL magic packets cannot reach the host. When the PC is powered off, it is not authorized, and the switch port is not opened.

When the switch uses IEEE 802.1x authentication with WoL, the switch forwards traffic to unauthorized IEEE 802.1x ports, including magic packets. While the port is unauthorized, the switch continues to block ingress traffic other than EAPOL packets. The host can receive packets but cannot send packets to other devices in the network.



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**Note** If PortFast is not enabled on the port, the port is forced to the bidirectional state.

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When you configure a port as unidirectional by using the **authentication control-direction in** interface configuration command, the port changes to the spanning-tree forwarding state. The port can send packets to the host but cannot receive packets from the host.

When you configure a port as bidirectional by using the **authentication control-direction both** interface configuration command, the port is access-controlled in both directions. The port does not receive packets from or send packets to the host.

## IEEE 802.1x Authentication with MAC Authentication Bypass

You can configure the switch to authorize clients based on the client MAC address by using the MAC authentication bypass feature. For example, you can enable this feature on IEEE 802.1x ports connected to devices such as printers.

If IEEE 802.1x authentication times out while waiting for an EAPOL response from the client, the switch tries to authorize the client by using MAC authentication bypass.

When the MAC authentication bypass feature is enabled on an IEEE 802.1x port, the switch uses the MAC address as the client identity. The authentication server has a database of client MAC addresses that are allowed network access. After detecting a client on an IEEE 802.1x port, the switch waits for an Ethernet packet from the client. The switch sends the authentication server a RADIUS-access/request frame with a username and password based on the MAC address. If authorization succeeds, the switch grants the client access to the network. If authorization fails, the switch assigns the port to the guest VLAN if one is configured. This process works for most client devices; however, it does not work for clients that use an alternate MAC address format. You can configure how MAB authentication is performed for clients with MAC addresses that deviate from the standard format or where the RADIUS configuration requires the user name and password to differ.

If an EAPOL packet is detected on the interface during the lifetime of the link, the switch determines that the device connected to that interface is an 802.1x-capable supplicant and uses 802.1x authentication (not MAC authentication bypass) to authorize the interface. EAPOL history is cleared if the interface link status goes down.

If the switch already authorized a port by using MAC authentication bypass and detects an IEEE 802.1x supplicant, the switch does not unauthorize the client connected to the port. When re-authentication occurs, the switch uses the authentication or re-authentication methods configured on the port, if the previous session ended because the Termination-Action RADIUS attribute value is `DEFAULT`.

Clients that were authorized with MAC authentication bypass can be re-authenticated. The re-authentication process is the same as that for clients that were authenticated with IEEE 802.1x. During re-authentication, the port remains in the previously assigned VLAN. If re-authentication is successful, the switch keeps the port in the same VLAN. If re-authentication fails, the switch assigns the port to the guest VLAN, if one is configured.

If re-authentication is based on the Session-Timeout RADIUS attribute (Attribute[27]) and the Termination-Action RADIUS attribute (Attribute [29]) and if the Termination-Action RADIUS attribute (Attribute [29]) action is *Initialize* (the attribute value is `DEFAULT`), the MAC authentication bypass session ends, and connectivity is lost during re-authentication. If MAC authentication bypass is enabled and the IEEE 802.1x authentication times out, the switch uses the MAC authentication bypass feature to initiate re-authorization. For more information about these AV pairs, see RFC 3580, “IEEE 802.1X Remote Authentication Dial In User Service (RADIUS) Usage Guidelines.”

MAC authentication bypass interacts with the features:

- IEEE 802.1x authentication—You can enable MAC authentication bypass only if 802.1x authentication is enabled on the port .
- Guest VLAN—If a client has an invalid MAC address identity, the switch assigns the client to a guest VLAN if one is configured.

- Restricted VLAN—This feature is not supported when the client connected to an IEEE 802.1x port is authenticated with MAC authentication bypass.
- Port security
- Voice VLAN
- Private VLAN—You can assign a client to a private VLAN.
- Network Edge Access Topology (NEAT)—MAB and NEAT are mutually exclusive. You cannot enable MAB when NEAT is enabled on an interface, and you should not enable NEAT when MAB is enabled on an interface.

Cisco IOS Release 12.2(55)SE and later supports filtering of verbose MAB system messages

## Network Admission Control Layer 2 IEEE 802.1x Validation

The switch supports the Network Admission Control (NAC) Layer 2 IEEE 802.1x validation, which checks the antivirus condition or *posture* of endpoint systems or clients before granting the devices network access. With NAC Layer 2 IEEE 802.1x validation, you can do these tasks:

- Download the Session-Timeout RADIUS attribute (Attribute[27]) and the Termination-Action RADIUS attribute (Attribute[29]) from the authentication server.
- Set the number of seconds between re-authentication attempts as the value of the Session-Timeout RADIUS attribute (Attribute[27]) and get an access policy against the client from the RADIUS server.
- Set the action to be taken when the switch tries to re-authenticate the client by using the Termination-Action RADIUS attribute (Attribute[29]). If the value is the *DEFAULT* or is not set, the session ends. If the value is RADIUS-Request, the re-authentication process starts.
- Set the list of VLAN number or name or VLAN group name as the value of the Tunnel Group Private ID (Attribute[81]) and the preference for the VLAN number or name or VLAN group name as the value of the Tunnel Preference (Attribute[83]). If you do not configure the Tunnel Preference, the first Tunnel Group Private ID (Attribute[81]) attribute is picked up from the list.
- View the NAC posture token, which shows the posture of the client, by using the **show authentication** privileged EXEC command.
- Configure secondary private VLANs as guest VLANs.

Configuring NAC Layer 2 IEEE 802.1x validation is similar to configuring IEEE 802.1x port-based authentication except that you must configure a posture token on the RADIUS server.

## Flexible Authentication Ordering

You can use flexible authentication ordering to configure the order of methods that a port uses to authenticate a new host. The IEEE 802.1X Flexible Authentication feature supports three authentication methods:

- dot1X—IEEE 802.1X authentication is a Layer 2 authentication method.
- mab—MAC-Authentication Bypass is a Layer 2 authentication method.
- webauth—Web authentication is a Layer 3 authentication method.

Using this feature, you can control which ports use which authentication methods, and you can control the failover sequencing of methods on those ports. For example, MAC authentication bypass and 802.1x can be the primary or secondary authentication methods, and web authentication can be the fallback method if either or both of those authentication attempts fail.

The IEEE 802.1X Flexible Authentication feature supports the following host modes:

- multi-auth—Multiauthentication allows one authentication on a voice VLAN and multiple authentications on the data VLAN.
- multi-domain—Multidomain authentication allows two authentications: one on the voice VLAN and one on the data VLAN.

### Related Topics

[Configuring Flexible Authentication Ordering](#), on page 2072

## Open1x Authentication

Open1x authentication allows a device access to a port before that device is authenticated. When open authentication is configured, a new host can pass traffic according to the access control list (ACL) defined on the port. After the host is authenticated, the policies configured on the RADIUS server are applied to that host.

You can configure open authentication with these scenarios:

- Single-host mode with open authentication—Only one user is allowed network access before and after authentication.
- MDA mode with open authentication—Only one user in the voice domain and one user in the data domain are allowed.
- Multiple-hosts mode with open authentication—Any host can access the network.
- Multiple-authentication mode with open authentication—Similar to MDA, except multiple hosts can be authenticated.



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**Note** If open authentication is configured, it takes precedence over other authentication controls. This means that if you use the **authentication open** interface configuration command, the port will grant access to the host irrespective of the **authentication port-control** interface configuration command.

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### Related Topics

[Configuring Open1x](#), on page 2073

## Multidomain Authentication

The switch supports multidomain authentication (MDA), which allows both a data device and voice device, such as an IP phone (Cisco or non-Cisco), to authenticate on the same switch port. The port is divided into a data domain and a voice domain.



**Note** For all host modes, the line protocol stays up before authorization when port-based authentication is configured.

MDA does not enforce the order of device authentication. However, for best results, we recommend that a voice device is authenticated before a data device on an MDA-enabled port.

Follow these guidelines for configuring MDA:

- You must configure a switch port for MDA.
- You must configure the voice VLAN for the IP phone when the host mode is set to multidomain.
- Voice VLAN assignment on an MDA-enabled port is supported Cisco IOS Release 12.2(40)SE and later.
- To authorize a voice device, the AAA server must be configured to send a Cisco Attribute-Value (AV) pair attribute with a value of *device-traffic-class=voice*. Without this value, the switch treats the voice device as a data device.
- The guest VLAN and restricted VLAN features only apply to the data devices on an MDA-enabled port. The switch treats a voice device that fails authorization as a data device.
- If more than one device attempts authorization on either the voice or the data domain of a port, it is error disabled.
- Until a device is authorized, the port drops its traffic. Non-Cisco IP phones or voice devices are allowed into both the data and voice VLANs. The data VLAN allows the voice device to contact a DHCP server to obtain an IP address and acquire the voice VLAN information. After the voice device starts sending on the voice VLAN, its access to the data VLAN is blocked.
- A voice device MAC address that is binding on the data VLAN is not counted towards the port security MAC address limit.
- MDA can use MAC authentication bypass as a fallback mechanism to allow the switch port to connect to devices that do not support IEEE 802.1x authentication.
- When a *data* or a *voice* device is detected on a port, its MAC address is blocked until authorization succeeds. If the authorization fails, the MAC address remains blocked for 5 minutes.
- If more than five devices are detected on the *data* VLAN or more than one voice device is detected on the *voice* VLAN while a port is unauthorized, the port is error disabled.
- When a port host mode is changed from single- or multihost to multidomain mode, an authorized data device remains authorized on the port. However, a Cisco IP phone that has been allowed on the port voice VLAN is automatically removed and must be reauthenticated on that port.
- Active fallback mechanisms such as guest VLAN and restricted VLAN remain configured after a port changes from single- or multihost mode to multidomain mode.
- Switching a port host mode from multidomain to single- or multihost mode removes all authorized devices from the port.
- If a data domain is authorized first and placed in the guest VLAN, non-IEEE 802.1x-capable voice devices need to tag their packets on the voice VLAN to trigger authentication.
- We do not recommend per-user ACLs with an MDA-enabled port. An authorized device with a per-user ACL policy might impact traffic on both the voice and data VLANs of the port. If used, only one device on the port should enforce per-user ACLs.

## 802.1x Supplicant and Authenticator Switches with Network Edge Access Topology (NEAT)

The Network Edge Access Topology (NEAT) feature extends identity to areas outside the wiring closet (such as conference rooms). This allows any type of device to authenticate on the port.

- **802.1x switch supplicant:** You can configure a switch to act as a supplicant to another switch by using the 802.1x supplicant feature. This configuration is helpful in a scenario, where, for example, a switch is outside a wiring closet and is connected to an upstream switch through a trunk port. A switch configured with the 802.1x switch supplicant feature authenticates with the upstream switch for secure connectivity. Once the supplicant switch authenticates successfully the port mode changes from access to trunk in an authenticator switch. In a supplicant switch you must manually configure trunk when enabling CISP.
- If the access VLAN is configured on the authenticator switch, it becomes the native VLAN for the trunk port after successful authentication.

In the default state, when you connect a supplicant switch to an authenticator switch that has BPD guard enabled, the authenticator port could be error-disabled if it receives a Spanning Tree Protocol (STP) bridge protocol data unit (BPDU) packets before the supplicant switch has authenticated. Beginning with Cisco IOS Release 15.0(1)SE, you can control traffic exiting the supplicant port during the authentication period. Entering the **dot1x supplicant controlled transient** global configuration command temporarily blocks the supplicant port during authentication to ensure that the authenticator port does not shut down before authentication completes. If authentication fails, the supplicant port opens. Entering the **no dot1x supplicant controlled transient** global configuration command opens the supplicant port during the authentication period. This is the default behavior.

We strongly recommend using the **dot1x supplicant controlled transient** command on a supplicant switch when BPD guard is enabled on the authenticator switch port with the **spanning-tree bpduguard enable** interface configuration command.




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**Note** If you globally enable BPD guard on the authenticator switch by using the **spanning-tree portfast bpduguard default** global configuration command, entering the **dot1x supplicant controlled transient** command does not prevent the BPD guard violation.

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You can enable MDA or multiauth mode on the authenticator switch interface that connects to one more supplicant switches. Multihost mode is not supported on the authenticator switch interface.

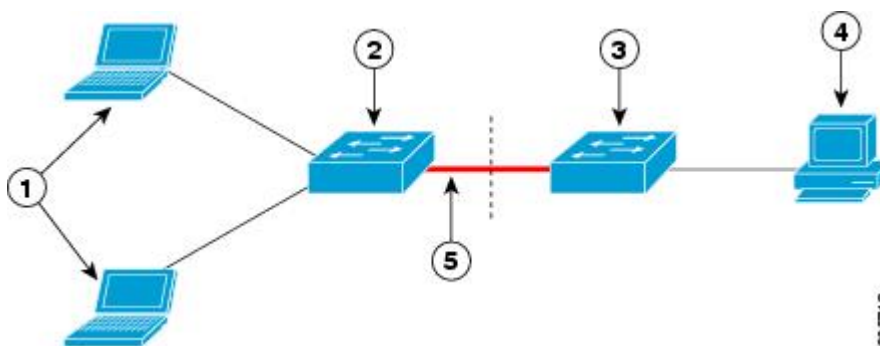
When you reboot an authenticator switch with single-host mode enabled on the interface, the interface may move to err-disabled state before authentication. To recover from err-disabled state, flap the authenticator port to activate the interface again and initiate authentication.

Use the **dot1x supplicant force-multicast** global configuration command on the supplicant switch for Network Edge Access Topology (NEAT) to work in all host modes.

- **Host Authorization:** Ensures that only traffic from authorized hosts (connecting to the switch with supplicant) is allowed on the network. The switches use Client Information Signalling Protocol (CISP) to send the MAC addresses connecting to the supplicant switch to the authenticator switch.
- **Auto enablement:** Automatically enables trunk configuration on the authenticator switch, allowing user traffic from multiple VLANs coming from supplicant switches. Configure the `cisco-av-pair as device-traffic-class=switch` at the ISE. (You can configure this under the `group` or the `user` settings.)



Figure 131: Authenticator and Supplicant Switch using CISP



1	Workstations (clients)	2	Supplicant switch (outside wiring closet)
3	Authenticator switch	4	Cisco ISE
5	Trunk port		



**Note** The `switchport nonegotiate` command is not supported on supplicant and authenticator switches with NEAT. This command should not be configured at the supplicant side of the topology. If configured on the authenticator side, the internal macros will automatically remove this command from the port.

## Voice Aware 802.1x Security



**Note** To use voice aware IEEE 802.1x authentication, the switch must be running the LAN base image.

You use the voice aware 802.1x security feature to configure the switch to disable only the VLAN on which a security violation occurs, whether it is a data or voice VLAN. In previous releases, when an attempt to authenticate the data client caused a security violation, the entire port shut down, resulting in a complete loss of connectivity.

You can use this feature in IP phone deployments where a PC is connected to the IP phone. A security violation found on the data VLAN results in the shutdown of only the data VLAN. The traffic on the voice VLAN flows through the switch without interruption.

### Related Topics

[Configuring Voice Aware 802.1x Security](#), on page 2034

## Common Session ID

Authentication manager uses a single session ID (referred to as a common session ID) for a client no matter which authentication method is used. This ID is used for all reporting purposes, such as the show commands and MIBs. The session ID appears with all per-session syslog messages.

The session ID includes:

- The IP address of the Network Access Device (NAD)
- A monotonically increasing unique 32 bit integer
- The session start time stamp (a 32 bit integer)

This example shows how the session ID appears in the output of the show authentication command. The session ID in this example is 160000050000000B288508E5:

```
Device# show authentication sessions
Interface  MAC Address      Method  Domain  Status      Session ID
Fa4/0/4    0000.0000.0203   mab     DATA   Authz Success 160000050000000B288508E5
```

This is an example of how the session ID appears in the syslog output. The session ID in this example is also 160000050000000B288508E5:

```
1w0d: %AUTHMGR-5-START: Starting 'mab' for client (0000.0000.0203) on Interface Fa4/0/4
AuditSessionID 160000050000000B288508E5
1w0d: %MAB-5-SUCCESS: Authentication successful for client (0000.0000.0203) on Interface
Fa4/0/4 AuditSessionID 160000050000000B288508E5
1w0d: %AUTHMGR-7-RESULT: Authentication result 'success' from 'mab' for client
(0000.0000.0203) on Interface Fa4/0/4 AuditSessionID 160000050000000B288508E5
```

The session ID is used by the NAD, the AAA server, and other report-analyzing applications to identify the client. The ID appears automatically. No configuration is required.

## How to Configure 802.1x Port-Based Authentication

### Default 802.1x Authentication Configuration

*Table 153: Default 802.1x Authentication Configuration*

Feature	Default Setting
Switch 802.1x enable state	Disabled.
Per-port 802.1x enable state	Disabled (force-authorized). The port sends and receives normal traffic without 802.1x-based authentication of the client.
AAA	Disabled.

Feature	Default Setting
RADIUS server <ul style="list-style-type: none"> <li>• IP address</li> <li>• UDP authentication port</li> <li>• Default accounting port</li> <li>• Key</li> </ul>	<ul style="list-style-type: none"> <li>• None specified.</li> <li>• 1645.</li> <li>• 1646.</li> <li>• None specified.</li> </ul>
Host mode	Single-host mode.
Control direction	Bidirectional control.
Periodic re-authentication	Disabled.
Number of seconds between re-authentication attempts	3600 seconds.
Re-authentication number	2 times (number of times that the switch restarts the authentication process before the port changes to the unauthorized state).
Quiet period	60 seconds (number of seconds that the switch remains in the quiet state following a failed authentication exchange with the client).
Retransmission time	30 seconds (number of seconds that the switch should wait for a response to an EAP request/identity frame from the client before resending the request).
Maximum retransmission number	2 times (number of times that the switch will send an EAP-request/identity frame before restarting the authentication process).
Client timeout period	30 seconds (when relaying a request from the authentication server to the client, the amount of time the switch waits for a response before resending the request to the client.)
Authentication server timeout period	30 seconds (when relaying a response from the client to the authentication server, the amount of time the switch waits for a reply before resending the response to the server.)  You can change this timeout period by using the dot1x timeout server-timeout interface configuration command.
Inactivity timeout	Disabled.
Guest VLAN	None specified.
Inaccessible authentication bypass	Disabled.

Feature	Default Setting
Restricted VLAN	None specified.
Authenticator (switch) mode	None specified.
MAC authentication bypass	Disabled.
Voice-aware security	Disabled.

## 802.1x Authentication Configuration Guidelines

### 802.1x Authentication

These are the 802.1x authentication configuration guidelines:

- You must enable SISF-Based device tracking to use 802.1x authentication. By default, SISF-Based device tracking is disabled on a switch.
- When 802.1x authentication is enabled, ports are authenticated before any other Layer 2 or Layer 3 features are enabled.
- If the VLAN to which an 802.1x-enabled port is assigned changes, this change is transparent and does not affect the switch. For example, this change occurs if a port is assigned to a RADIUS server-assigned VLAN and is then assigned to a different VLAN after re-authentication.

If the VLAN to which an 802.1x port is assigned to shut down, disabled, or removed, the port becomes unauthorized. For example, the port is unauthorized after the access VLAN to which a port is assigned shuts down or is removed.

- The 802.1x protocol is supported on Layer 2 static-access ports, voice VLAN ports, and Layer 3 routed ports, but it is not supported on these port types:
  - Dynamic ports—A port in dynamic mode can negotiate with its neighbor to become a trunk port. If you try to enable 802.1x authentication on a dynamic port, an error message appears, and 802.1x authentication is not enabled. If you try to change the mode of an 802.1x-enabled port to dynamic, an error message appears, and the port mode is not changed.
  - EtherChannel port—Do not configure a port that is an active or a not-yet-active member of an EtherChannel as an 802.1x port. If you try to enable 802.1x authentication on an EtherChannel port, an error message appears, and 802.1x authentication is not enabled.
  - Switched Port Analyzer (SPAN) and Remote SPAN (RSPAN) destination ports—You can enable 802.1x authentication on a port that is a SPAN or RSPAN destination port. However, 802.1x authentication is disabled until the port is removed as a SPAN or RSPAN destination port. You can enable 802.1x authentication on a SPAN or RSPAN source port.
- Before globally enabling 802.1x authentication on a switch by entering the **dot1x system-auth-control** global configuration command, remove the EtherChannel configuration from the interfaces on which 802.1x authentication and EtherChannel are configured.
- Cisco IOS Release 12.2(55)SE and later supports filtering of system messages related to 802.1x authentication.

## VLAN Assignment, Guest VLAN, Restricted VLAN, and Inaccessible Authentication Bypass

These are the configuration guidelines for VLAN assignment, guest VLAN, restricted VLAN, and inaccessible authentication bypass:

- When 802.1x authentication is enabled on a port, you cannot configure a port VLAN that is equal to a voice VLAN.
- You can configure any VLAN except an RSPAN VLAN or a voice VLAN as an 802.1x guest VLAN. The guest VLAN feature is not supported on internal VLANs (routed ports) or trunk ports; it is supported only on access ports.
- After you configure a guest VLAN for an 802.1x port to which a DHCP client is connected, you might need to get a host IP address from a DHCP server. You can change the settings for restarting the 802.1x authentication process on the switch before the DHCP process on the client times out and tries to get a host IP address from the DHCP server. Decrease the settings for the 802.1x authentication process (**authentication timer inactivity** and **authentication timer reauthentication** interface configuration commands). The amount to decrease the settings depends on the connected 802.1x client type.
- When configuring the inaccessible authentication bypass feature, follow these guidelines:
  - The feature is supported on 802.1x port in single-host mode and multihosts mode.
  - If the client is running Windows XP and the port to which the client is connected is in the critical-authentication state, Windows XP might report that the interface is not authenticated.
  - If the Windows XP client is configured for DHCP and has an IP address from the DHCP server, receiving an EAP-Success message on a critical port might not re-initiate the DHCP configuration process.
  - You can configure the inaccessible authentication bypass feature and the restricted VLAN on an 802.1x port. If the switch tries to re-authenticate a critical port in a restricted VLAN and all the RADIUS servers are unavailable, switch changes the port state to the critical authentication state and remains in the restricted VLAN.
  - If the CTS links are in Critical Authentication mode and the master reloads, the policy where SGT was configured on a device will not be available on the new master. This is because the internal bindings will not be synced to the standby switch in a 3750-X switch stack.
- You can configure any VLAN except an RSPAN VLAN or a voice VLAN as an 802.1x restricted VLAN. The restricted VLAN feature is not supported on internal VLANs (routed ports) or trunk ports; it is supported only on access ports.
- When wireless guest clients obtains IP from foreign client VLAN instead of anchor client VLAN, you should use the **ip dhcp required** command under the WLAN configuration to force clients to issue a new DHCP request. This prevents the clients from getting an incorrect IP at anchor.
- If the wired guest clients fail to get IP address after a Cisco WLC (foreign) reload, perform a shut/no shut on the ports used by the clients to reconnect them.

## MAC Authentication Bypass

These are the MAC authentication bypass configuration guidelines:

- Unless otherwise stated, the MAC authentication bypass guidelines are the same as the 802.1x authentication guidelines.

- If you disable MAC authentication bypass from a port after the port has been authorized with its MAC address, the port state is not affected.
- If the port is in the unauthorized state and the client MAC address is not the authentication-server database, the port remains in the unauthorized state. However, if the client MAC address is added to the database, the switch can use MAC authentication bypass to re-authorize the port.
- If the port is in the authorized state, the port remains in this state until re-authorization occurs.
- You can configure a timeout period for hosts that are connected by MAC authentication bypass but are inactive. The range is 1 to 65535 seconds.

## Maximum Number of Allowed Devices Per Port

This is the maximum number of devices allowed on an 802.1x-enabled port:

- In single-host mode, only one device is allowed on the access VLAN. If the port is also configured with a voice VLAN, an unlimited number of Cisco IP phones can send and receive traffic through the voice VLAN.
- In multidomain authentication (MDA) mode, one device is allowed for the access VLAN, and one IP phone is allowed for the voice VLAN.
- In multihost mode, only one 802.1x supplicant is allowed on the port, but an unlimited number of non-802.1x hosts are allowed on the access VLAN. An unlimited number of devices are allowed on the voice VLAN.

## Configuring 802.1x Readiness Check

The 802.1x readiness check monitors 802.1x activity on all the switch ports and displays information about the devices connected to the ports that support 802.1x. You can use this feature to determine if the devices connected to the switch ports are 802.1x-capable.

The 802.1x readiness check is allowed on all ports that can be configured for 802.1x. The readiness check is not available on a port that is configured as **dot1x force-unauthorized**.

Follow these steps to enable the 802.1x readiness check on the switch:

### Before you begin

Follow these guidelines to enable the readiness check on the switch:

- The readiness check is typically used before 802.1x is enabled on the switch.
- If you use the **dot1x test eapol-capable** privileged EXEC command without specifying an interface, all the ports on the switch stack are tested.
- When you configure the **dot1x test eapol-capable** command on an 802.1x-enabled port, and the link comes up, the port queries the connected client about its 802.1x capability. When the client responds with a notification packet, it is 802.1x-capable. A syslog message is generated if the client responds within the timeout period. If the client does not respond to the query, the client is not 802.1x-capable. No syslog message is generated.
- When you configure the **dot1x test eapol-capable** command on an 802.1x-enabled port, and the link comes up, the port queries the connected client about its 802.1x capability. When the client responds with a notification packet, it is 802.1x-capable. A syslog message is generated if the client responds

within the timeout period. If the client does not respond to the query, the client is not 802.1x-capable. No syslog message is generated

- The readiness check can be sent on a port that handles multiple hosts (for example, a PC that is connected to an IP phone). A syslog message is generated for each of the clients that respond to the readiness check within the timer period.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>dot1x test eapol-capable [interface interface-id]</b> <b>Example:</b> Device# <b>dot1x test eapol-capable interface gigabitethernet1/0/13</b> DOT1X_PORT_EAPOL_CAPABLE:DOT1X: MAC 00-01-02-4b-f1-a3 on gigabitethernet1/0/13 is EAPOL capable	Enables the 802.1x readiness check on the switch. (Optional) For <i>interface-id</i> specify the port on which to check for IEEE 802.1x readiness. <b>Note</b> If you omit the optional <b>interface</b> keyword, all interfaces on the switch are tested.
<b>Step 4</b>	<b>dot1x test timeout timeout</b>	(Optional) Configures the timeout used to wait for EAPOL response. The range is from 1 to 65535 seconds. The default is 10 seconds.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config</b>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	<code>startup-config</code>	

**Related Topics**

[802.1x Readiness Check](#), on page 2011

## Configuring Voice Aware 802.1x Security



**Note** To use voice aware IEEE 802.1x authentication, the switch must be running the LAN base image.

You use the voice aware 802.1x security feature on the switch to disable only the VLAN on which a security violation occurs, whether it is a data or voice VLAN. You can use this feature in IP phone deployments where a PC is connected to the IP phone. A security violation found on the data VLAN results in the shutdown of only the data VLAN. The traffic on the voice VLAN flows through the switch without interruption.

Follow these guidelines to configure voice aware 802.1x voice security on the switch:

- You enable voice aware 802.1x security by entering the **errdisable detect cause security-violation shutdown vlan** global configuration command. You disable voice aware 802.1x security by entering the **no** version of this command. This command applies to all 802.1x-configured ports in the switch.



**Note** If you do not include the **shutdown vlan** keywords, the entire port is shut down when it enters the error-disabled state.

- If you use the **errdisable recovery cause security-violation** global configuration command to configure error-disabled recovery, the port is automatically re-enabled. If error-disabled recovery is not configured for the port, you re-enable it by using the **shutdown** and **no shutdown** interface configuration commands.
- You can re-enable individual VLANs by using the **clear errdisable interface interface-id vlan [vlan-list]** privileged EXEC command. If you do not specify a range, all VLANs on the port are enabled.

Beginning in privileged EXEC mode, follow these steps to enable voice aware 802.1x security:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<code>configure terminal</code>	Enter global configuration mode.
<b>Step 2</b>	<code>errdisable detect cause security-violation shutdown vlan</code>	Shut down any VLAN on which a security violation error occurs.  <b>Note</b> If the <b>shutdown vlan</b> keywords are not included, the entire port enters the error-disabled state and shuts down.



	Command or Action	Purpose
<b>Step 3</b>	<b>errdisable recovery cause security-violation</b>	Enter global configuration mode.
<b>Step 4</b>	<b>clear errdisable interface</b> <i>interface-id</i> <b>vlan</b> <i>[vlan-list]</i>	(Optional) Reenable individual VLANs that have been error disabled. <ul style="list-style-type: none"> <li>• For interface-id specify the port on which to reenable individual VLANs.</li> <li>• (Optional) For vlan-list specify a list of VLANs to be re-enabled. If vlan-list is not specified, all VLANs are re-enabled.</li> </ul>
<b>Step 5</b>	Enter the following: <ul style="list-style-type: none"> <li>• <b>shutdown</b></li> <li>• <b>no shutdown</b></li> </ul>	(Optional) Re-enable an error-disabled VLAN, and clear all error-disable indications.
<b>Step 6</b>	<b>end</b>	Return to privileged EXEC mode.
<b>Step 7</b>	<b>show errdisable detect</b>	Verify your entries.

### Example

This example shows how to configure the switch to shut down any VLAN on which a security violation error occurs:

```
Switch(config)# errdisable detect cause security-violation shutdown vlan
```

This example shows how to re-enable all VLANs that were error disabled on port Gigabit Ethernet 40/2.

```
Switch# clear errdisable interface gigabitethernet40/2  
vlan
```

You can verify your settings by entering the **show errdisable detect** privileged EXEC command.

### Related Topics

[Voice Aware 802.1x Security](#), on page 2027

## Configuring 802.1x Violation Modes

You can configure an 802.1x port so that it shuts down, generates a syslog error, or discards packets from a new device when:

- a device connects to an 802.1x-enabled port
- the maximum number of allowed about devices have been authenticated on the port

Beginning in privileged EXEC mode, follow these steps to configure the security violation actions on the switch:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>aaa new-model</b> <b>Example:</b> Device(config)# <b>aaa new-model</b>	Enables AAA.
<b>Step 3</b>	<b>aaa authentication dot1x {default} method1</b> <b>Example:</b> Device(config)# <b>aaa authentication dot1x default group radius</b>	Creates an 802.1x authentication method list.  To create a default list that is used when a named list is <i>not</i> specified in the <b>authentication</b> command, use the <b>default</b> keyword followed by the method that is to be used in default situations. The default method list is automatically applied to all ports.  For <i>method1</i> , enter the <b>group radius</b> keywords to use the list of all RADIUS servers for authentication.
<b>Step 4</b>	<b>interface interface-id</b> <b>Example:</b> Device(config)# <b>interface gigabitethernet1/0/4</b>	Specifies the port connected to the client that is to be enabled for IEEE 802.1x authentication, and enter interface configuration mode.
<b>Step 5</b>	<b>switchport mode access</b> <b>Example:</b> Device(config-if)# <b>switchport mode access</b>	Sets the port to access mode.
<b>Step 6</b>	<b>authentication violation {shutdown   restrict   protect   replace}</b> <b>Example:</b> Device(config-if)# <b>authentication violation restrict</b>	Configures the violation mode. The keywords have these meanings: <ul style="list-style-type: none"> <li>• <b>shutdown</b>—Error disable the port.</li> <li>• <b>restrict</b>—Generate a syslog error.</li> <li>• <b>protect</b>—Drop packets from any new device that sends traffic to the port.</li> <li>• <b>replace</b>—Removes the current session and authenticates with the new host.</li> </ul>

	Command or Action	Purpose
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring 802.1x Authentication

To allow per-user ACLs or VLAN assignment, you must enable AAA authorization to configure the switch for all network-related service requests.

This is the 802.1x AAA process:

### Before you begin

To configure 802.1x port-based authentication, you must enable authentication, authorization, and accounting (AAA) and specify the authentication method list. A method list describes the sequence and authentication method to be queried to authenticate a user.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	A user connects to a port on the switch.	
<b>Step 2</b>	Authentication is performed.	
<b>Step 3</b>	VLAN assignment is enabled, as appropriate, based on the RADIUS server configuration.	
<b>Step 4</b>	The switch sends a start message to an accounting server.	
<b>Step 5</b>	Re-authentication is performed, as necessary.	
<b>Step 6</b>	The switch sends an interim accounting update to the accounting server that is based on the result of re-authentication.	
<b>Step 7</b>	The user disconnects from the port.	
<b>Step 8</b>	The switch sends a stop message to the accounting server.	

## Configuring 802.1x Port-Based Authentication

Beginning in privileged EXEC mode, follow these steps to configure 802.1x port-based authentication:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>aaa new-model</b> <b>Example:</b> Device (config)# <code>aaa new-model</code>	Enables AAA.
<b>Step 3</b>	<b>aaa authentication dot1x {default} method1</b> <b>Example:</b> Device (config)# <code>aaa authentication dot1x default group radius</code>	<p>Creates an 802.1x authentication method list.</p> <p>To create a default list that is used when a named list is <i>not</i> specified in the <b>authentication</b> command, use the <b>default</b> keyword followed by the method that is to be used in default situations. The default method list is automatically applied to all ports.</p> <p>For <i>method1</i>, enter the <b>group radius</b> keywords to use the list of all RADIUS servers for authentication.</p> <p><b>Note</b> Though other keywords are visible in the command-line help string, only the <b>group radius</b> keywords are supported.</p>
<b>Step 4</b>	<b>dot1x system-auth-control</b> <b>Example:</b> Device (config)# <code>dot1x system-auth-control</code>	Enables 802.1x authentication globally on the switch.
<b>Step 5</b>	<b>aaa authorization network {default} group radius</b> <b>Example:</b> Device (config)# <code>aaa authorization network default group radius</code>	(Optional) Configures the switch to use user-RADIUS authorization for all network-related service requests, such as per-user ACLs or VLAN assignment.
<b>Step 6</b>	<b>radius server <i>server name</i></b> <b>Example:</b> Device (config)# <code>radius server rsim</code>	(Optional) Specifies the IP address of the RADIUS server.

	Command or Action	Purpose
	<code>address ipv4 124.2.2.12</code>	
<b>Step 7</b>	<b>address {ipv4   ipv6} ip address</b> <b>Example:</b> Device(config-radius-server)# <b>address ipv4 10.0.1.12</b>	Configures the IP address for the RADIUS server.
<b>Step 8</b>	<b>key string</b> <b>Example:</b> Device(config-radius-server)# <b>key rad123</b>	(Optional) Specifies the authentication and encryption key used between the switch and the RADIUS daemon running on the RADIUS server.
<b>Step 9</b>	<b>exit</b> <b>Example:</b> Device(config-radius-server)# <b>exit</b>	Exits the RADIUS server mode and enters the global configuration mode.
<b>Step 10</b>	<b>interface interface-id</b> <b>Example:</b> Device(config)# <b>interface gigabitethernet1/0/2</b>	Specifies the port connected to the client that is to be enabled for IEEE 802.1x authentication, and enter interface configuration mode.
<b>Step 11</b>	<b>switchport mode access</b> <b>Example:</b> Device(config-if)# <b>switchport mode access</b>	(Optional) Sets the port to access mode only if you configured the RADIUS server in Step 6 and Step 7.
<b>Step 12</b>	<b>authentication port-control auto</b> <b>Example:</b> Device(config-if)# <b>authentication port-control auto</b>	Enables 802.1x authentication on the port.
<b>Step 13</b>	<b>dot1x pae authenticator</b> <b>Example:</b> Device(config-if)# <b>dot1x pae authenticator</b>	Sets the interface Port Access Entity to act only as an authenticator and ignore messages meant for a supplicant.

	Command or Action	Purpose
<b>Step 14</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring the Switch-to-RADIUS-Server Communication

You can globally configure the timeout, retransmission, and encryption key values for all RADIUS servers by using the **radius server** global configuration command. If you want to configure these options on a per-server basis, use the **radius-server timeout**, the **radius-server retransmit**, and the **key string** global configuration commands.

You also need to configure some settings on the RADIUS server. These settings include the IP address of the switch and the key string to be shared by both the server and the switch. For more information, see the RADIUS server documentation.

Follow these steps to configure the RADIUS server parameters on the switch. This procedure is required.

### Before you begin

You must enable authentication, authorization, and accounting (AAA) and specify the authentication method list. A method list describes the sequence and authentication method to be queried to authenticate a user.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>radius server</b> <i>server name</i> <b>Example:</b> Device(config)# <b>radius server rsim</b>	Specifies the name the RADIUS server and enters radius server configuration mode.
<b>Step 4</b>	<b>address</b> { <b>ipv4</b>   <b>ipv6</b> } <i>ip address</i> <b>auth-port</b> <i>port number</i> <b>acct-port</b> <i>port number</i>	Specifies the IP address of the RADIUS server.

	Command or Action	Purpose
	<b>Example:</b> Device(config-radius-server) # <b>address</b> <b>ipv4 124.2.2.12</b>	For <b>auth-port</b> <i>port-number</i> , specify the UDP destination port for authentication requests. The default is 1645. The range is 0 to 65536.  For <b>acct-port</b> <i>port-number</i> , specify the UDP destination port for authentication requests. The default is 1646.
<b>Step 5</b>	<b>key string</b>  <b>Example:</b> Device(config-radius-server) # <b>key rad123</b>	Specifies the authentication and encryption key used between the Device and the RADIUS daemon running on the RADIUS server.  <b>Note</b> The key is a text string that must match the encryption key used on the RADIUS server. Always configure the key as the last item in the <b>radius server</b> command. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key.
<b>Step 6</b>	<b>end</b>  <b>Example:</b> Device(config) # <b>end</b>	Returns to privileged EXEC mode.

## Configuring the Host Mode

Beginning in privileged EXEC mode, follow these steps to allow multiple hosts (clients) on an IEEE 802.1x-authorized port that has the **authentication port-control** interface configuration command set to **auto**. Use the **multi-domain** keyword to configure and enable multidomain authentication (MDA), which allows both a host and a voice device, such as an IP phone (Cisco or non-Cisco), on the same switch port. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> <pre>Device(config)# interface gigabitethernet2/0/1</pre>	Specifies the port to which multiple hosts are indirectly attached, and enter interface configuration mode.
<b>Step 3</b>	<b>authentication host-mode</b> [ <b>multi-auth</b>   <b>multi-domain</b>   <b>multi-host</b>   <b>single-host</b> ] <b>Example:</b> <pre>Device(config-if)# authentication host-mode multi-host</pre>	<p>Allows multiple hosts (clients) on an 802.1x-authorized port.</p> <p>The keywords have these meanings:</p> <ul style="list-style-type: none"> <li>• <b>multi-auth</b>—Allow multiple authenticated clients on both the voice VLAN and data VLAN.</li> </ul> <p><b>Note</b> The <b>multi-auth</b> keyword is only available with the <b>authentication host-mode</b> command.</p> <ul style="list-style-type: none"> <li>• <b>multi-host</b>—Allow multiple hosts on an 802.1x-authorized port after a single host has been authenticated.</li> <li>• <b>multi-domain</b>—Allow both a host and a voice device, such as an IP phone (Cisco or non-Cisco), to be authenticated on an IEEE 802.1x-authorized port.</li> </ul> <p><b>Note</b> You must configure the voice VLAN for the IP phone when the host mode is set to <b>multi-domain</b>.</p> <p>Make sure that the <b>authentication port-control</b> interface configuration command is set to <b>auto</b> for the specified interface.</p>
<b>Step 4</b>	<b>end</b> <b>Example:</b> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.

## Configuring Periodic Re-Authentication

You can enable periodic 802.1x client re-authentication and specify how often it occurs. If you do not specify a time period before enabling re-authentication, the number of seconds between attempts is 3600.



Beginning in privileged EXEC mode, follow these steps to enable periodic re-authentication of the client and to configure the number of seconds between re-authentication attempts. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet2/0/1</b>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 3</b>	<b>authentication periodic</b> <b>Example:</b> Device(config-if)# <b>authentication periodic</b>	Enables periodic re-authentication of the client, which is disabled by default.  <b>Note</b> The default value is 3600 seconds. To change the value of the reauthentication timer or to have the switch use a RADIUS-provided session timeout, enter the <b>authentication timer reauthenticate</b> command.
<b>Step 4</b>	<b>authentication timer {[inactivity   reauthenticate   restart   unauthorized]} {value}}</b> <b>Example:</b> Device(config-if)# <b>authentication timer reauthenticate 180</b>	Sets the number of seconds between re-authentication attempts.  The <b>authentication timer</b> keywords have these meanings: <ul style="list-style-type: none"> <li>• <b>inactivity</b>—Interval in seconds after which if there is no activity from the client then it is unauthorized</li> <li>• <b>reauthenticate</b>—Time in seconds after which an automatic re-authentication attempt is initiated</li> <li>• <b>restart <i>value</i></b>—Interval in seconds after which an attempt is made to authenticate an unauthorized port</li> <li>• <b>unauthorized <i>value</i></b>—Interval in seconds after which an unauthorized session will get deleted</li> </ul>

	Command or Action	Purpose
		This command affects the behavior of the switch only if periodic re-authentication is enabled.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-if) # <b>end</b>	Returns to privileged EXEC mode.

## Changing the Quiet Period

When the switch cannot authenticate the client, the switch remains idle for a set period of time and then tries again. The **authentication timer restart** interface configuration command controls the idle period. A failed authentication of the client might occur because the client provided an invalid password. You can provide a faster response time to the user by entering a number smaller than the default.

Beginning in privileged EXEC mode, follow these steps to change the quiet period. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface</b> <b>gigabitethernet2/0/1</b>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 3</b>	<b>authentication timer restart <i>seconds</i></b> <b>Example:</b> Device(config-if) # <b>authentication timer</b> <b>restart 30</b>	Sets the number of seconds that the switch remains in the quiet state following a failed authentication exchange with the client. The range is 1 to 65535 seconds; the default is 60.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config-if) # <b>end</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 5</b>	<b>show authentication sessions interface</b> <i>interface-id</i>  <b>Example:</b>  Device# <b>show authentication sessions</b> <b>interface gigabitethernet2/0/1</b>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

## Changing the Switch-to-Client Retransmission Time

The client responds to the EAP-request/identity frame from the switch with an EAP-response/identity frame. If the switch does not receive this response, it waits a set period of time (known as the retransmission time) and then resends the frame.



**Note** You should change the default value of this command only to adjust for unusual circumstances such as unreliable links or specific behavioral problems with certain clients and authentication servers.

Beginning in privileged EXEC mode, follow these steps to change the amount of time that the switch waits for client notification. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface</b> <i>interface-id</i>  <b>Example:</b>  Device(config)# <b>interface</b> <b>gigabitethernet2/0/1</b>	Specifies the port to be configured, and enter interface configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>authentication timer reauthenticate</b> <i>seconds</i> <b>Example:</b> Device (config-if) # <b>authentication timer reauthenticate 60</b>	Sets the number of seconds that the switch waits for a response to an EAP-request/identity frame from the client before resending the request. The range is 1 to 65535 seconds; the default is 5.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device (config-if) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show authentication sessions interface</b> <i>interface-id</i> <b>Example:</b> Device# <b>show authentication sessions interface gigabitethernet2/0/1</b>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Setting the Switch-to-Client Frame-Retransmission Number

In addition to changing the switch-to-client retransmission time, you can change the number of times that the switch sends an EAP-request/identity frame (assuming no response is received) to the client before restarting the authentication process.



### Note

You should change the default value of this command only to adjust for unusual circumstances such as unreliable links or specific behavioral problems with certain clients and authentication servers.

Beginning in privileged EXEC mode, follow these steps to set the switch-to-client frame-retransmission number. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 2</b>	<code>interface interface-id</code> <b>Example:</b>  Device(config)# <code>interface gigabitethernet2/0/1</code>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 3</b>	<code>dot1x max-reauth-req count</code> <b>Example:</b>  Device(config-if)# <code>dot1x max-reauth-req 5</code>	Sets the number of times that the switch sends an EAP-request/identity frame to the client before restarting the authentication process. The range is 1 to 10; the default is 2.
<b>Step 4</b>	<code>end</code> <b>Example:</b>  Device(config-if)# <code>end</code>	Returns to privileged EXEC mode.

## Setting the Re-Authentication Number

You can also change the number of times that the switch restarts the authentication process before the port changes to the unauthorized state.



**Note** You should change the default value of this command only to adjust for unusual circumstances such as unreliable links or specific behavioral problems with certain clients and authentication servers.

Beginning in privileged EXEC mode, follow these steps to set the re-authentication number. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>configure terminal</code> <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<code>interface interface-id</code> <b>Example:</b>	Specifies the port to be configured, and enter interface configuration mode.

	Command or Action	Purpose
	Device# <code>interface gigabitethernet2/0/1</code>	
<b>Step 3</b>	<b>switchport mode access</b> <b>Example:</b>  Device(config-if)# <code>switchport mode access</code>	Sets the port to access mode only if you previously configured the RADIUS server.
<b>Step 4</b>	<b>dot1x max-req count</b> <b>Example:</b>  Device(config-if)# <code>dot1x max-req 4</code>	Sets the number of times that the switch restarts the authentication process before the port changes to the unauthorized state. The range is 0 to 10; the default is 2.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config-if)# <code>end</code>	Returns to privileged EXEC mode.

## Enabling MAC Move

MAC move allows an authenticated host to move from one port on the switch to another.

Beginning in privileged EXEC mode, follow these steps to globally enable MAC move on the switch. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>authentication mac-move permit</b> <b>Example:</b>  Device(config)# <code>authentication mac-move permit</code>	Enables MAC move on the switch. Default is deny.  In Session Aware Networking mode, the default CLI is <b>access-session mac-move deny</b> . To enable Mac Move in Session Aware Networking, use the <b>no access-session mac-move</b> global configuration command.  In legacy mode (IBNS 1.0), default value for <b>mac-move</b> is <b>deny</b> and in C3PL mode (IBNS 2.0) default value is <b>permit</b> .

	Command or Action	Purpose
<b>Step 3</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 4</b>	<b>show running-config</b> <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 5</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Enabling MAC Replace

MAC replace allows a host to replace an authenticated host on a port.

Beginning in privileged EXEC mode, follow these steps to enable MAC replace on an interface. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device(config)# <b>interface gigabitethernet2/0/2</b>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 3</b>	<b>authentication violation {protect   replace   restrict   shutdown}</b> <b>Example:</b>  Device(config-if)# <b>authentication</b>	Use the <b>replace</b> keyword to enable MAC replace on the interface. The port removes the current session and initiates authentication with the new host.  The other keywords have these effects:

	Command or Action	Purpose
	<code>violation replace</code>	<ul style="list-style-type: none"> <li>• <b>protect</b>: the port drops packets with unexpected MAC addresses without generating a system message.</li> <li>• <b>restrict</b>: violating packets are dropped by the CPU and a system message is generated.</li> <li>• <b>shutdown</b>: the port is error disabled when it receives an unexpected MAC address.</li> </ul>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring 802.1x Accounting

Enabling AAA system accounting with 802.1x accounting allows system reload events to be sent to the accounting RADIUS server for logging. The server can then infer that all active 802.1x sessions are closed.



**Note** In Cisco IOS XE Denali 16.3.x and Cisco IOS XE Everest 16.6.x, periodic AAA accounting updates are not supported. The switch does not send periodic interim accounting records to the accounting server. Periodic AAA accounting updates are available in Cisco IOS XE Fuji 16.9.x and later releases.

Because RADIUS uses the unreliable UDP transport protocol, accounting messages might be lost due to poor network conditions. If the switch does not receive the accounting response message from the RADIUS server after a configurable number of retransmissions of an accounting request, this system message appears:

```
Accounting message %s for session %s failed to receive Accounting Response.
```

When the stop message is not sent successfully, this message appears:



```
00:09:55: %RADIUS-4-RADIUS_DEAD: RADIUS server 172.20.246.201:1645,1646 is not responding.
```



**Note** You must configure the RADIUS server to perform accounting tasks, such as logging start, stop, and interim-update messages and time stamps. To turn on these functions, enable logging of “Update/Watchdog packets from this AAA client” in your RADIUS server Network Configuration tab. Next, enable “CVS RADIUS Accounting” in your RADIUS server System Configuration tab.

Beginning in privileged EXEC mode, follow these steps to configure 802.1x accounting after AAA is enabled on your switch. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device(config)# <b>interface gigabitethernet1/0/3</b>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 3</b>	<b>aaa accounting dot1x default start-stop group radius</b> <b>Example:</b>  Device(config-if)# <b>aaa accounting dot1x default start-stop group radius</b>	Enables 802.1x accounting using the list of all RADIUS servers.
<b>Step 4</b>	<b>aaa accounting system default start-stop group radius</b> <b>Example:</b>  Device(config-if)# <b>aaa accounting system default start-stop group radius</b>	(Optional) Enables system accounting (using the list of all RADIUS servers) and generates system accounting reload event messages when the switch reloads.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 6</b>	<b>show running-config</b> <b>Example:</b> Device# <code>show running-config</code>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring a Guest VLAN

When you configure a guest VLAN, clients that are not 802.1x-capable are put into the guest VLAN when the server does not receive a response to its EAP request/identity frame. Clients that are 802.1x-capable but that fail authentication are not granted network access. The switch supports guest VLANs in single-host or multiple-hosts mode.

Beginning in privileged EXEC mode, follow these steps to configure a guest VLAN. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device (config)# <code>interface gigabitethernet 2/0/2</code>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 3</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>switchport mode access</b></li> <li>• <b>switchport mode private-vlan host</b></li> </ul> <b>Example:</b> Device (config-if)# <code>switchport mode private-vlan host</code>	<ul style="list-style-type: none"> <li>• Sets the port to access mode.</li> <li>• Configures the Layer 2 port as a private-VLAN host port.</li> </ul>

	Command or Action	Purpose
<b>Step 4</b>	<b>authentication event no-response action authorize vlan <i>vlan-id</i></b>  <b>Example:</b>  Device(config-if)# <b>authentication event no-response action authorize vlan 2</b>	Specifies an active VLAN as an 802.1x guest VLAN. The range is 1 to 4094.  You can configure any active VLAN except an internal VLAN (routed port), an RSPAN VLAN or a voice VLAN as an 802.1x guest VLAN.
<b>Step 5</b>	<b>end</b>  <b>Example:</b>  Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring a Restricted VLAN

When you configure a restricted VLAN on a switch stack or a switch, clients that are IEEE 802.1x-compliant are moved into the restricted VLAN when the authentication server does not receive a valid username and password. The switch supports restricted VLANs only in single-host mode.

Beginning in privileged EXEC mode, follow these steps to configure a restricted VLAN. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b>  <b>Example:</b>  Device(config)# <b>interface gigabitethernet 2/0/2</b>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 3</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>switchport mode access</b></li> <li>• <b>switchport mode private-vlan host</b></li> </ul> <b>Example:</b>  Device(config-if)# <b>switchport mode access</b>	<ul style="list-style-type: none"> <li>• Sets the port to access mode.</li> <li>• Configures the Layer 2 port as a private-VLAN host port.</li> </ul>

	Command or Action	Purpose
<b>Step 4</b>	<b>authentication port-control auto</b> <b>Example:</b> <pre>Device(config-if) # authentication port-control auto</pre>	Enables 802.1x authentication on the port.
<b>Step 5</b>	<b>authentication event fail action authorize vlan <i>vlan-id</i></b> <b>Example:</b> <pre>Device(config-if) # authentication event fail action authorize vlan 2</pre>	Specifies an active VLAN as an 802.1x restricted VLAN. The range is 1 to 4094.  You can configure any active VLAN except an internal VLAN (routed port), an RSPAN VLAN or a voice VLAN as an 802.1x restricted VLAN.
<b>Step 6</b>	<b>end</b> <b>Example:</b> <pre>Device(config-if) # end</pre>	Returns to privileged EXEC mode.

## Configuring Number of Authentication Attempts on a Restricted VLAN

You can configure the maximum number of authentication attempts allowed before a user is assigned to the restricted VLAN by using the **authentication event retry *retry count*** interface configuration command. The range of allowable authentication attempts is 1 to 3. The default is 3 attempts.

Beginning in privileged EXEC mode, follow these steps to configure the maximum number of allowed authentication attempts. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> <pre>Device(config) # interface gigabitethernet 2/0/3</pre>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 3</b>	Use one of the following: <ul style="list-style-type: none"> <li>• <b>switchport mode access</b></li> </ul>	<ul style="list-style-type: none"> <li>• Sets the port to access mode.</li> </ul>

	Command or Action	Purpose
	<ul style="list-style-type: none"> <li><code>switchport mode private-vlan host</code></li> </ul> <b>Example:</b> or <pre>Device(config-if)# switchport mode access</pre>	<ul style="list-style-type: none"> <li>Configures the Layer 2 port as a private-VLAN host port.</li> </ul>
<b>Step 4</b>	<b>authentication port-control auto</b> <b>Example:</b> <pre>Device(config-if)# authentication port-control auto</pre>	Enables 802.1x authentication on the port.
<b>Step 5</b>	<b>authentication event fail action authorize vlan <i>vlan-id</i></b> <b>Example:</b> <pre>Device(config-if)# authentication event fail action authorize vlan 8</pre>	<p>Specifies an active VLAN as an 802.1x restricted VLAN. The range is 1 to 4094.</p> <p>You can configure any active VLAN except an internal VLAN (routed port), an RSPAN VLAN or a voice VLAN as an 802.1x restricted VLAN.</p>
<b>Step 6</b>	<b>authentication event retry <i>retry count</i></b> <b>Example:</b> <pre>Device(config-if)# authentication event retry 2</pre>	<p>Specifies a number of authentication attempts to allow before a port moves to the restricted VLAN. The range is 1 to 3, and the default is 3.</p>
<b>Step 7</b>	<b>end</b> <b>Example:</b> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.

## Configuring 802.1x Inaccessible Authentication Bypass with Critical Voice VLAN

Beginning in privileged EXEC mode, follow these steps to configure critical voice VLAN on a port and enable the inaccessible authentication bypass feature.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>aaa new-model</b> <b>Example:</b> Device (config)# <b>aaa new-model</b>	Enables AAA.
<b>Step 3</b>	<b>radius-server dead-criteria {time <i>seconds</i> } [tries <i>number</i>]</b> <b>Example:</b> Device (config)# <b>radius-server dead-criteria time 20 tries 10</b>	Sets the conditions that determine when a RADIUS server is considered un-available or down (dead). <ul style="list-style-type: none"> <li>• <b>time</b>— 1 to 120 seconds. The switch dynamically determines a default <i>seconds</i> value between 10 and 60.</li> <li>• <b>number</b>—1 to 100 tries. The switch dynamically determines a default <i>triesnumber</i> between 10 and 100.</li> </ul>
<b>Step 4</b>	<b>radius-server deadtime <i>minutes</i></b> <b>Example:</b> Device (config)# <b>radius-server deadtime 60</b>	(Optional) Sets the number of minutes during which a RADIUS server is not sent requests. The range is from 0 to 1440 minutes (24 hours). The default is 0 minutes.
<b>Step 5</b>	<b>radius server <i>server name</i></b> <b>Example:</b> Device (config)# <b>radius server rsim address ipv4 124.2.2.12</b>	(Optional) Specifies the IP address of the RADIUS server.
<b>Step 6</b>	<b>address {ipv4   ipv6} <i>ip address</i> auth-port <i>port_number</i> acct-port <i>port_number</i></b> <b>Example:</b> Device (config-radius-server)# <b>address ipv4 10.0.1.2 auth-port 1550 acct-port 1560</b>	Configures the IP address for the RADIUS server.

	Command or Action	Purpose
<b>Step 7</b>	<b>key string</b> <b>Example:</b> <pre>Device(config-radius-server)# key rad123</pre>	(Optional) Specifies the authentication and encryption key used between the switch and the RADIUS daemon running on the RADIUS server.
<b>Step 8</b>	<b>exit</b> <b>Example:</b> <pre>Device(config-radius-server)# exit</pre>	Exits the RADIUS server mode and enters the global configuration mode.
<b>Step 9</b>	<b>dot1x critical {eapol   recovery delay milliseconds}</b> <b>Example:</b> <pre>Device(config)# dot1x critical eapol (config)# dot1x critical recovery delay 2000</pre>	(Optional) Configure the parameters for inaccessible authentication bypass: <ul style="list-style-type: none"> <li>• <b>eapol</b>—Specify that the switch sends an EAPOL-Success message when the switch successfully authenticates the critical port.</li> <li>• <b>recovery delay milliseconds</b>—Set the recovery delay period during which the switch waits to re-initialize a critical port when a RADIUS server that was unavailable becomes available. The range is from 1 to 10000 milliseconds. The default is 1000 milliseconds (a port can be re-initialized every second).</li> </ul>
<b>Step 10</b>	<b>interface interface-id</b> <b>Example:</b> <pre>Device(config)# interface gigabitethernet 1/0/1</pre>	Specify the port to be configured, and enter interface configuration mode.
<b>Step 11</b>	<b>authentication event server dead action {authorize   reinitialize} vlan vlan-id]</b> <b>Example:</b> <pre>Device(config-if)# authentication event server dead action reinitialicze vlan 20</pre>	Use these keywords to move hosts on the port if the RADIUS server is unreachable: <ul style="list-style-type: none"> <li>• <b>authorize</b>—Move any new hosts trying to authenticate to the user-specified critical VLAN.</li> <li>• <b>reinitialize</b>—Move all authorized hosts on the port to the user-specified critical VLAN.</li> </ul>

	Command or Action	Purpose
<b>Step 12</b>	<b>switchport voice vlan <i>vlan-id</i></b> <b>Example:</b> Device(config-if)# <b>switchport voice vlan</b>	Specifies the voice VLAN for the port. The voice VLAN cannot be the same as the critical data VLAN configured in Step 6.
<b>Step 13</b>	<b>authentication event server dead action authorize voice</b> <b>Example:</b> Device(config-if)# <b>authentication event server dead action authorize voice</b>	Configures critical voice VLAN to move data traffic on the port to the voice VLAN if the RADIUS server is unreachable.
<b>Step 14</b>	<b>show authentication interface <i>interface-id</i></b> <b>Example:</b> Device(config-if)# <b>do show authentication interface gigabit 1/0/1</b>	(Optional) Verify your entries.
<b>Step 15</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device(config-if)# <b>do copy running-config startup-config</b>	(Optional) Verify your entries.

### Example

To return to the RADIUS server default settings, use the **no radius-server dead-criteria**, the **no radius-server deadtime**, and the **no radius server** global configuration commands. To disable inaccessible authentication bypass, use the **no authentication event server dead action** interface configuration command. To disable critical voice VLAN, use the **no authentication event server dead action authorize voice** interface configuration command.

## Example of Configuring Inaccessible Authentication Bypass

This example shows how to configure the inaccessible authentication bypass feature:

```
Device(config)# radius-server dead-criteria time 30 tries 20
Device(config)# radius-server deadtime 60
Device(config)# radius server server1
Device(config-radius-server)# address ipv4 172.29.36.49 acct-port 1618 auth-port 1612
Device(config-radius-server)# key abc1234
Device(config-radius-server)# exit
Device(config)# dot1x critical eapol
```



```

Device(config)# dot1x critical recovery delay 2000
Device(config)# interface gigabitethernet 1/0/1
Device(config-if)# dot1x critical
Device(config-if)# dot1x critical recovery action reinitialize
Device(config-if)# dot1x critical vlan 20
Device(config-if)# end

```

## Configuring 802.1x Authentication with WoL

Beginning in privileged EXEC mode, follow these steps to enable 802.1x authentication with WoL. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface</b> <b>gigabitethernet2/0/3</b>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 3</b>	<b>authentication control-direction {both   in}</b> <b>Example:</b> Device(config-if)# <b>authentication</b> <b>control-direction both</b>	Enables 802.1x authentication with WoL on the port, and use these keywords to configure the port as bidirectional or unidirectional. <ul style="list-style-type: none"> <li>• <b>both</b>—Sets the port as bidirectional. The port cannot receive packets from or send packets to the host. By default, the port is bidirectional.</li> <li>• <b>in</b>—Sets the port as unidirectional. The port can send packets to the host but cannot receive packets from the host.</li> </ul>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show authentication sessions interface</b> <b><i>interface-id</i></b> <b>Example:</b>	Verifies your entries.

	Command or Action	Purpose
	Device# <code>show authentication sessions interface gigabitethernet2/0/3</code>	
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Configuring MAC Authentication Bypass

Beginning in privileged EXEC mode, follow these steps to enable MAC authentication bypass. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <code>interface gigabitethernet 2/0/1</code>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 3</b>	<b>authentication port-control auto</b> <b>Example:</b> Device(config-if)# <code>authentication port-control auto</code>	Enables 802.1x authentication on the port.
<b>Step 4</b>	<b>mab [eap]</b> <b>Example:</b> Device(config-if)# <code>mab</code>	Enables MAC authentication bypass. (Optional) Use the <b>eap</b> keyword to configure the switch to use EAP for authorization.
<b>Step 5</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	Device(config-if) # <b>end</b>	

## Configuring 802.1x User Distribution

Beginning in privileged EXEC mode, follow these steps to configure a VLAN group and to map a VLAN to it:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>vlan group <i>vlan-group-name</i> vlan-list <i>vlan-list</i></b> <b>Example:</b> Device(config) # <b>vlan group eng-dept vlan-list 10</b>	Configures a VLAN group, and maps a single VLAN or a range of VLANs to it.
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 4</b>	<b>no vlan group <i>vlan-group-name</i> vlan-list <i>vlan-list</i></b> <b>Example:</b> Device(config) # <b>no vlan group eng-dept vlan-list 10</b>	Clears the VLAN group configuration or elements of the VLAN group configuration.

### Example of Configuring VLAN Groups

This example shows how to configure the VLAN groups, to map the VLANs to the groups, to and verify the VLAN group configurations and mapping to the specified VLANs:

```
Device(config) # vlan group eng-dept vlan-list 10

Device(config) # show vlan group group-name eng-dept
Group Name                Vlans Mapped
-----                -----
```

```

eng-dept                               10

Device(config)# show dot1x vlan-group all
Group Name                               Vlans Mapped
-----
eng-dept                                 10
hr-dept                                  20

```

This example shows how to add a VLAN to an existing VLAN group and to verify that the VLAN was added:

```

Device(config)# vlan group eng-dept vlan-list 30
Device(config)# show vlan group eng-dept
Group Name                               Vlans Mapped
-----
eng-dept                                 10,30

```

This example shows how to remove a VLAN from a VLAN group:

```
Device# no vlan group eng-dept vlan-list 10
```

This example shows that when all the VLANs are cleared from a VLAN group, the VLAN group is cleared:

```

Device(config)# no vlan group eng-dept vlan-list 30
Vlan 30 is successfully cleared from vlan group eng-dept.

Device(config)# show vlan group group-name eng-dept

```

This example shows how to clear all the VLAN groups:

```

Device(config)# no vlan group eng-dept vlan-list all
Device(config)# show vlan-group all

```

For more information about these commands, see the *Cisco IOS Security Command Reference*.

## Configuring NAC Layer 2 802.1x Validation

You can configure NAC Layer 2 802.1x validation, which is also referred to as 802.1x authentication with a RADIUS server.

Beginning in privileged EXEC mode, follow these steps to configure NAC Layer 2 802.1x validation. The procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> Device(config)# <b>interface</b> <b>gigabitethernet2/0/3</b>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 3</b>	<b>switchport mode access</b> <b>Example:</b> Device(config-if)# <b>switchport mode access</b>	Sets the port to access mode only if you configured the RADIUS server.
<b>Step 4</b>	<b>authentication event no-response action</b> <b>authorize vlan</b> <i>vlan-id</i> <b>Example:</b> Device(config-if)# <b>authentication event</b> <b>no-response action authorize vlan 8</b>	<p>Specifies an active VLAN as an 802.1x guest VLAN. The range is 1 to 4094.</p> <p>You can configure any active VLAN except an internal VLAN (routed port), an RSPAN VLAN, or a voice VLAN as an 802.1x guest VLAN.</p>
<b>Step 5</b>	<b>authentication periodic</b> <b>Example:</b> Device(config-if)# <b>authentication</b> <b>periodic</b>	Enables periodic re-authentication of the client, which is disabled by default.
<b>Step 6</b>	<b>authentication timer reauthenticate</b> <b>Example:</b> Device(config-if)# <b>authentication timer</b> <b>reauthenticate</b>	<p>Sets re-authentication attempt for the client (set to one hour).</p> <p>This command affects the behavior of the switch only if periodic re-authentication is enabled.</p>
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show authentication sessions interface</b> <i>interface-id</i> <b>Example:</b> Device# <b>show authentication sessions</b> <b>interface gigabitethernet2/0/3</b>	Verifies your entries.

	Command or Action	Purpose
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring an Authenticator Switch with NEAT

Configuring this feature requires that one switch outside a wiring closet is configured as a supplicant and is connected to an authenticator switch.



### Note

- The authenticator switch interface configuration must be restored to access mode by explicitly flapping it if a line card is removed and inserted in the chassis when CISP or NEAT session is active.
- The *cisco-av-pairs* must be configured as *device-traffic-class=switch* on the ISE, which sets the interface as a trunk after the supplicant is successfully authenticated.

Beginning in privileged EXEC mode, follow these steps to configure a switch as an authenticator:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<b>cisp enable</b> <b>Example:</b> <pre>Device(config)# cisp enable</pre>	Enables CISP.
<b>Step 3</b>	<b>interface interface-id</b> <b>Example:</b> <pre>Device(config)# interface gigabitethernet 2/0/1</pre>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 4</b>	<b>switchport mode access</b> <b>Example:</b>	Sets the port mode to <b>access</b> .

	Command or Action	Purpose
	Device (config-if) # <b>switchport mode access</b>	
<b>Step 5</b>	<b>authentication port-control auto</b> <b>Example:</b> Device (config-if) # <b>authentication port-control auto</b>	Sets the port-authentication mode to auto.
<b>Step 6</b>	<b>dot1x pae authenticator</b> <b>Example:</b> Device (config-if) # <b>dot1x pae authenticator</b>	Configures the interface as a port access entity (PAE) authenticator.
<b>Step 7</b>	<b>spanning-tree portfast</b> <b>Example:</b> Device (config-if) # <b>spanning-tree portfast trunk</b>	Enables Port Fast on an access port connected to a single workstation or server..
<b>Step 8</b>	<b>end</b> <b>Example:</b> Device (config-if) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 9</b>	<b>show running-config interface <i>interface-id</i></b> <b>Example:</b> Device# <b>show running-config interface gigabitethernet 2/0/1</b>	Verifies your configuration.
<b>Step 10</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.  <b>Note</b> Saving changes to the configuration file will mean that the authenticator interface will continue to be in trunk mode after reload. If you want the authenticator interface to remain as an access port, do not save your changes to the configuration file.

## Configuring a Supplicant Switch with NEAT

Beginning in privileged EXEC mode, follow these steps to configure a switch as a supplicant:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>cisp enable</b> <b>Example:</b>  Device (config)# <b>cisp enable</b>	Enables CISP.
<b>Step 3</b>	<b>dot1x credentials <i>profile</i></b> <b>Example:</b>  Device (config)# <b>dot1x credentials test</b>	Creates 802.1x credentials profile. This must be attached to the port that is configured as supplicant.
<b>Step 4</b>	<b>username <i>suppswitch</i></b> <b>Example:</b>  Device (config)# <b>username suppswitch</b>	Creates a username.
<b>Step 5</b>	<b>password <i>password</i></b> <b>Example:</b>  Device (config)# <b>password myswitch</b>	Creates a password for the new username.
<b>Step 6</b>	<b>dot1x supplicant force-multicast</b> <b>Example:</b>  Device (config)# <b>dot1x supplicant force-multicast</b>	Forces the switch to send only multicast EAPOL packets when it receives either unicast or multicast packets.  This also allows NEAT to work on the supplicant switch in all host modes.
<b>Step 7</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device (config)# <b>interface gigabitethernet1/0/1</b>	Specifies the port to be configured, and enter interface configuration mode.



	Command or Action	Purpose
<b>Step 8</b>	<b>switchport trunk encapsulation dot1q</b> <b>Example:</b> <pre>Device(config-if)# switchport trunk encapsulation dot1q</pre>	Sets the port to trunk mode.
<b>Step 9</b>	<b>switchport mode trunk</b> <b>Example:</b> <pre>Device(config-if)# switchport mode trunk</pre>	Configures the interface as a VLAN trunk port.
<b>Step 10</b>	<b>dot1x pae supplicant</b> <b>Example:</b> <pre>Device(config-if)# dot1x pae supplicant</pre>	Configures the interface as a port access entity (PAE) supplicant.
<b>Step 11</b>	<b>dot1x credentials <i>profile-name</i></b> <b>Example:</b> <pre>Device(config-if)# dot1x credentials test</pre>	Attaches the 802.1x credentials profile to the interface.
<b>Step 12</b>	<b>end</b> <b>Example:</b> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.
<b>Step 13</b>	<b>show running-config interface <i>interface-id</i></b> <b>Example:</b> <pre>Device# show running-config interface gigabitethernet1/0/1</pre>	Verifies your configuration.
<b>Step 14</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.
<b>Step 15</b>	Configuring NEAT with Auto Smartports Macros	You can also use an Auto Smartports user-defined macro instead of the switch VSA to configure the authenticator switch. For more

	Command or Action	Purpose
		information, see the <i>Auto Smartports Configuration Guide</i> for this release.

## Configuring 802.1x Authentication with Downloadable ACLs and Redirect URLs



**Note** You must configure a downloadable ACL on the ACS before downloading it to the switch.

After authentication on the port, you can use the **show ip access-list** privileged EXEC command to display the downloaded ACLs on the port.

### Configuring Downloadable ACLs

The policies take effect after client authentication and the client IP address addition to the IP device tracking table. The switch then applies the downloadable ACL to the port.

Beginning in privileged EXEC mode:

#### Before you begin

SISF-Based device tracking is a prerequisite to configuring 802.1x authentication. Ensure that you have enabled device tracking programmatically or manually. For more information, see the *Configuring SISF-Based Tracking* chapter.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>aaa new-model</b> <b>Example:</b> Device(config)# <code>aaa new-model</code>	Enables AAA.
<b>Step 3</b>	<b>aaa authorization network default local group radius</b> <b>Example:</b> Device(config)# <code>aaa authorization network default local group radius</code>	Sets the authorization method to local. To remove the authorization method, use the <b>no aaa authorization network default local group radius</b> command.

	Command or Action	Purpose
<b>Step 4</b>	<b>radius-server vsa send authentication</b> <b>Example:</b> <pre>Device(config)# radius-server vsa send authentication</pre>	Configures the radius vsa send authentication.
<b>Step 5</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> <pre>Device(config)# interface gigabitethernet2/0/4</pre>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 6</b>	<b>ip access-group <i>acl-id</i> in</b> <b>Example:</b> <pre>Device(config-if)# ip access-group default_acl in</pre>	Configures the default ACL on the port in the input direction. <b>Note</b> The <i>acl-id</i> is an access list name or number.
<b>Step 7</b>	<b>show running-config interface <i>interface-id</i></b> <b>Example:</b> <pre>Device(config-if)# show running-config interface gigabitethernet2/0/4</pre>	Verifies your configuration.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring a Downloadable Policy

Beginning in privileged EXEC mode:

### Before you begin

SISF-Based device tracking is a prerequisite to configuring 802.1x authentication. Ensure that you have enabled device tracking programmatically or manually.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 2</b>	<p><b>access-list</b> <i>access-list-number</i> { <b>deny</b>   <b>permit</b> } { <b>hostname</b>   <b>any</b>   <b>host</b> } <b>log</b></p> <p><b>Example:</b></p> <pre>Device(config)# access-list 1 deny any log</pre>	<p>Defines the default port ACL.</p> <p>The access-list-number is a decimal number from 1 to 99 or 1300 to 1999.</p> <p>Enter <b>deny</b> or <b>permit</b> to specify whether to deny or permit access if conditions are matched.</p> <p>The source is the source address of the network or host that sends a packet, such as this:</p> <ul style="list-style-type: none"> <li>• <b>hostname</b>: The 32-bit quantity in dotted-decimal format.</li> <li>• <b>any</b>: The keyword any as an abbreviation for source and source-wildcard value of 0.0.0.0 255.255.255.255. You do not need to enter a source-wildcard value.</li> <li>• <b>host</b>: The keyword host as an abbreviation for source and source-wildcard of source 0.0.0.0.</li> </ul> <p>(Optional) Applies the source-wildcard wildcard bits to the source.</p> <p>(Optional) Enters log to cause an informational logging message about the packet that matches the entry to be sent to the console.</p>
<b>Step 3</b>	<p><b>interface</b> <i>interface-id</i></p> <p><b>Example:</b></p> <pre>Device(config)# interface gigabitethernet2/0/2</pre>	Enters interface configuration mode.
<b>Step 4</b>	<p><b>ip access-group</b> <i>acl-id</i> <b>in</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# ip access-group default_acl in</pre>	<p>Configures the default ACL on the port in the input direction.</p> <p><b>Note</b> The acl-id is an access list name or number.</p>
<b>Step 5</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# exit</pre>	Returns to global configuration mode.

	Command or Action	Purpose
<b>Step 6</b>	<b>aaa new-model</b> <b>Example:</b> Device(config)# <b>aaa new-model</b>	Enables AAA.
<b>Step 7</b>	<b>aaa authorization network default group radius</b> <b>Example:</b> Device(config)# <b>aaa authorization network default group radius</b>	Sets the authorization method to local. To remove the authorization method, use the <b>no aaa authorization network default group radius</b> command.
<b>Step 8</b>	<b>radius-server vsa send authentication</b> <b>Example:</b> Device(config)# <b>radius-server vsa send authentication</b>	Configures the network access server to recognize and use vendor-specific attributes.  <b>Note</b> The downloadable ACL must be operational.
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring VLAN ID-based MAC Authentication

Beginning in privileged EXEC mode, follow these steps:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>mab request format attribute 32 vlan access-vlan</b> <b>Example:</b> Device(config)# <b>mab request format attribute 32 vlan access-vlan</b>	Enables VLAN ID-based MAC authentication.

	Command or Action	Purpose
<b>Step 3</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring Flexible Authentication Ordering

The examples used in the instructions below changes the order of Flexible Authentication Ordering so that MAB is attempted before IEEE 802.1X authentication (dot1x). MAB is configured as the first authentication method, so MAB will have priority over all other authentication methods.



### Note

Before changing the default order and priority of these authentication methods, however, you should understand the potential consequences of those changes. See [http://www.cisco.com/en/US/prod/collateral/iosswrel/ps6537/ps6586/ps6638/application\\_note\\_c27-573287\\_ps6638\\_Products\\_White\\_Paper.html](http://www.cisco.com/en/US/prod/collateral/iosswrel/ps6537/ps6586/ps6638/application_note_c27-573287_ps6638_Products_White_Paper.html) for details.

Beginning in privileged EXEC mode, follow these steps:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> <pre>Device(config)# interface gigabitethernet 1/0/1</pre>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 3</b>	<b>switchport mode access</b> <b>Example:</b> <pre>Device(config-if)# switchport mode access</pre>	Sets the port to access mode only if you previously configured the RADIUS server.
<b>Step 4</b>	<b>authentication order [ dot1x   mab ]   {webauth}</b> <b>Example:</b>	(Optional) Sets the order of authentication methods used on a port.

	Command or Action	Purpose
	Device(config-if)# <b>authentication order mab dot1x</b>	
<b>Step 5</b>	<b>authentication priority [ dot1x   mab ]   {webauth}</b> <b>Example:</b> Device(config-if)# <b>authentication priority mab dot1x</b>	(Optional) Adds an authentication method to the port-priority list.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

**Related Topics**

[Flexible Authentication Ordering](#), on page 2023

## Configuring Open1x

Beginning in privileged EXEC mode, follow these steps to enable manual control of the port authorization state:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/1</b>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 3</b>	<b>switchport mode access</b> <b>Example:</b> Device(config-if)# <b>switchport mode access</b>	Sets the port to access mode only if you configured the RADIUS server.

	Command or Action	Purpose
<b>Step 4</b>	<b>authentication control-direction</b> {both   in} <b>Example:</b> <pre>Device(config-if)# authentication control-direction both</pre>	(Optional) Configures the port control as unidirectional or bidirectional.
<b>Step 5</b>	<b>authentication fallback</b> <i>name</i> <b>Example:</b> <pre>Device(config-if)# authentication fallback profile1</pre>	(Optional) Configures a port to use web authentication as a fallback method for clients that do not support 802.1x authentication.
<b>Step 6</b>	<b>authentication host-mode</b> [multi-auth   multi-domain   multi-host   single-host] <b>Example:</b> <pre>Device(config-if)# authentication host-mode multi-auth</pre>	(Optional) Sets the authorization manager mode on a port.
<b>Step 7</b>	<b>authentication open</b> <b>Example:</b> <pre>Device(config-if)# authentication open</pre>	(Optional) Enables or disable open access on a port.
<b>Step 8</b>	<b>authentication order</b> [ dot1x   mab ]   {webauth} <b>Example:</b> <pre>Device(config-if)# authentication order dot1x webauth</pre>	(Optional) Sets the order of authentication methods used on a port.
<b>Step 9</b>	<b>authentication periodic</b> <b>Example:</b> <pre>Device(config-if)# authentication periodic</pre>	(Optional) Enables or disable reauthentication on a port.
<b>Step 10</b>	<b>authentication port-control</b> {auto   force-authorized   force-un authorized} <b>Example:</b> <pre>Device(config-if)# authentication port-control auto</pre>	(Optional) Enables manual control of the port authorization state.



	Command or Action	Purpose
<b>Step 11</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.

**Related Topics**

[Open1x Authentication](#), on page 2024

## Disabling 802.1x Authentication on the Port

You can disable 802.1x authentication on the port by using the **no dot1x pae** interface configuration command.

Beginning in privileged EXEC mode, follow these steps to disable 802.1x authentication on the port. This procedure is optional.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 2/0/1</b>	Specifies the port to be configured, and enter interface configuration mode.
<b>Step 3</b>	<b>switchport mode access</b> <b>Example:</b> Device(config-if)# <b>switchport mode access</b>	(Optional) Sets the port to access mode only if you configured the RADIUS server.
<b>Step 4</b>	<b>no dot1x pae authenticator</b> <b>Example:</b> Device(config-if)# <b>no dot1x pae authenticator</b>	Disables 802.1x authentication on the port.
<b>Step 5</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	Device (config-if) # <b>end</b>	

## Resetting the 802.1x Authentication Configuration to the Default Values

Beginning in privileged EXEC mode, follow these steps to reset the 802.1x authentication configuration to the default values. This procedure is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>  Device (config) # <b>interface gigabitethernet 1/0/2</b>	Enters interface configuration mode, and specify the port to be configured.
<b>Step 3</b>	<b>dot1x default</b> <b>Example:</b>  Device (config-if) # <b>dot1x default</b>	Resets the 802.1x parameters to the default values.
<b>Step 4</b>	<b>end</b> <b>Example:</b>  Device (config-if) # <b>end</b>	Returns to privileged EXEC mode.

## Monitoring 802.1x Statistics and Status

Table 154: Privileged EXEC show Commands

Command	Purpose
<b>show dot1x all statistics</b>	Displays 802.1x statistics for all ports
<b>show dot1x interface <i>interface-id</i> statistics</b>	Displays 802.1x statistics for a specific port

Command	Purpose
<b>show dot1x all</b> [ <b>count</b>   <b>details</b>   <b>statistics</b>   <b>summary</b> ]	Displays the 802.1x administrative and operational status for a switch
<b>show dot1x interface</b> <i>interface-id</i>	Displays the 802.1x administrative and operational status for a specific port

Table 155: Global Configuration Commands

Command	Purpose
<b>no dot1x logging verbose</b>	Filters verbose 802.1x authentication messages (beginning with Cisco IOS Release 12.2(55)SE)

For detailed information about the fields in these displays, see the command reference for this release.

## Additional References for IEEE 802.1x Port-Based Authentication

### Related Documents

Related Topic	Document Title
Configuring Identity Control policies and Identity Service templates for Session Aware networking.	Session Aware Networking Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches) <a href="http://www.cisco.com/en/US/docs/ios-xml/ios/san/configuration/xe-3se/3850/san-xe-3se-3850-book.htm">http://www.cisco.com/en/US/docs/ios-xml/ios/san/configuration/xe-3se/3850/san-xe-3se-3850-book.htm</a>
Configuring RADIUS, TACACS+, Secure Shell, 802.1X and AAA.	Securing User Services Configuration Guide Library, Cisco IOS XE Release 3SE (Catalyst 3850 Switches) <a href="http://www.cisco.com/en/US/docs/ios-xml/ios/security/config_library/xe-3se/3850/secuser-xe-3se-3850-l">http://www.cisco.com/en/US/docs/ios-xml/ios/security/config_library/xe-3se/3850/secuser-xe-3se-3850-l</a>

**Error Message Decoder**

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>



## CHAPTER 111

# Configuring Device Sensor

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- [About Device Sensor, on page 2079](#)
- [MSP-IOS Sensor Device Classifier Interaction, on page 2080](#)
- [Configuring Device Sensor, on page 2081](#)
- [Configuration Examples for the Device Sensor Feature, on page 2086](#)
- [Feature Information for Device Sensor, on page 2087](#)

## About Device Sensor

Device Sensor uses protocols such as Cisco Discovery Protocol (CDP), Link Layer Discovery Protocol (LLDP), and DHCP to obtain endpoint information from network devices and make this information available to its clients. Device Sensor has internal clients, such as the embedded Device Classifier (local analyzer), Auto Smartports (ASP), MediaNet Service Interface Media Services Proxy, and EnergyWise. Device Sensor also has an external client, Identity Services Engine (ISE), which uses RADIUS accounting to receive and analyze endpoint data. When integrated with ISE, Device Sensor provides central policy management and device-profiling capabilities.



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**Note** Cisco Identity Services Engine (ISE) based profiling is not supported on the LAN Base image.

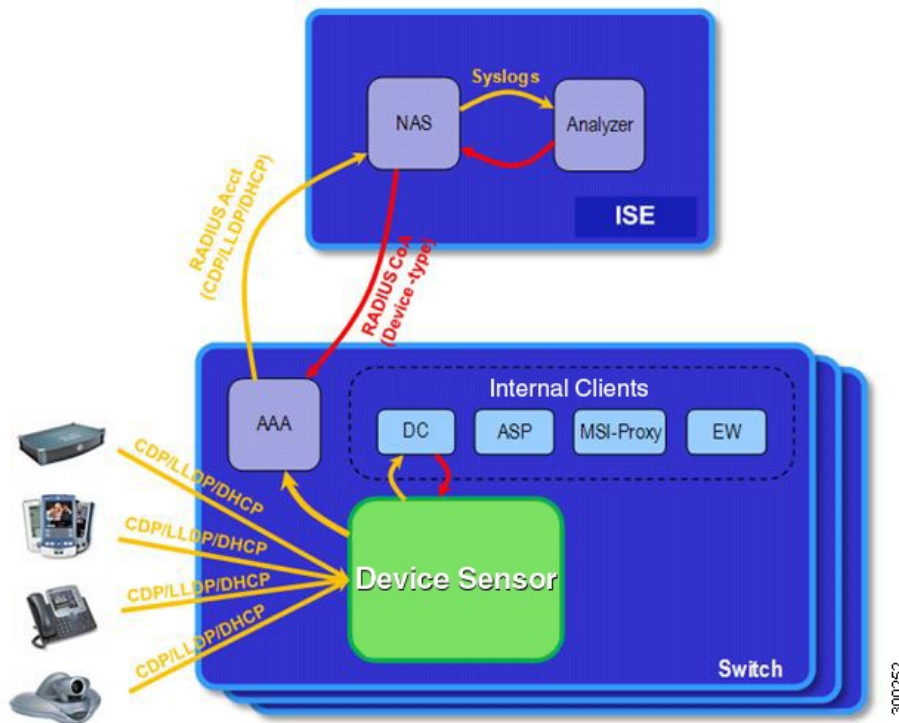
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Device profiling capability consists of two parts:

- Collector--Gathers endpoint data from network devices.
- Analyzer--Processes the data and determines the type of device.

Device Sensor represents the embedded collector functionality. The following illustration shows a Device Sensor in the context of its internal clients and the ISE

Figure 132: Device Sensor Clients



Client notifications and accounting messages that contain profiling data and other session-related data are generated and sent to the internal clients and the ISE. By default, client notifications and accounting events are generated only when an incoming packet includes a Type-Length-Value (TLV) that has not previously been received within a given access session. You can enable client notifications and accounting events for TLV changes; that is, when a previously received TLV is received with a different value.

Device Sensor port security protects a switch from consuming memory and crashing during deliberate or unintentional denial-of-service (DoS)-type attacks. Device Sensor limits the maximum number of device monitoring sessions to 32 per port. While hosts are inactive, the age session limit is 12 hours.

## MSP-IOS Sensor Device Classifier Interaction



**Note** To enable MSP, you must configure the profile flow command. Once done, when SIP, H323, or mDNS traffic are present, appropriate (SIP, H323, or mDNS) TLV notifications are sent to the IOS sensor.

MSP (Media Service Proxy) offers bandwidth reservation for audio or video flows and Metadata services to 3rd-party endpoints. To offer and install Media services, MSP must identify flow attributes and device details. MSP device identification requires automatic identification of various media end points in the network, thereby avoiding any change to the installed end point base. To offer MSP device discovery services, MSP leverages current IOS sensor capability for device classification. (Starting with Release IOS XE 3.3.0SG and IOS 15.1(1)SG, IOS sensor can be used to perform device identification. MSP uses the same functionality with the addition of SIP, H323, and Multicast DNS (mDNS) protocols.) Starting with Release IOS XE 3.4.0SG

and IOS 15.1(2)SG, MSP offers Media services to two kinds of media endpoints: IP Surveillance Cameras and Video-Conferencing Endpoints. Surveillance cameras are identified using mDNS protocol whereas Video-conference-Endpoints are identified using SIP and H.323 protocols.

mDNS compatible devices (Axis, Pelco cameras etc) send mDNS messages for DNS service discovery to a multicast IP address (224.0.0.251) on a standard mDNS port 5353. The mDNS client module listens to this UDP port, receives the mDNS message, and sends it in TLV format to the mDNS IOS sensor shim for further device classification. The module parses the mDNS query and Answer messages fields to create these TLVs.

A Session Initiation Protocol (SIP) registration message is used for SIP based device-discovery and is sent to Cisco Call manager by the SIP Client. A H.225 RAS client registration message is used for H323-based device discovery.

If no Cisco Unified Communicator Manager or GateKeeper exists in the topology, the Endpoint will not generate device Register messages. To handle device discovery in these scenarios, MSP expects the endpoint to make a SIP or H323 call so that MSP snoops the SIP invite or the H323 setup message to identify endpoint details and notify the IOS sensor.

After the IOS sensor receives these protocol details from MSP, the IOS sensor prepares Normalized TLVs, with the new protocols. These protocol details are sent to session manager for further classification.

## Configuring Device Sensor

Device Sensor is enabled by default. Complete the following tasks when you want Device Sensor to include or exclude a list of TLVs (termed filter lists) for a particular protocol.



**Note** If you do not perform any Device Sensor configuration tasks, the following TLVs are included by default:

- CDP filter--secondport-status-type and powernet-event-type (types 28 and 29)
- LLDP filter--organizationally-specific (type 127)
- DHCP filter--message-type (type 53)

## Enabling MSP

You must configure the MSP profile flow command to activate the MSP platform Packet parser. This is because the MSP device handler is tightly coupled with MSP flow parser. Not enabling this command means that MSP will not send SIP, H323 notifications to the IOS sensor.

To enable MSP, follow these steps, beginning in privileged EXEC mode:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	configure terminal  <b>Example:</b> Switch# configure terminal	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	profile flow  <b>Example:</b> Switch(config)# profile flow	Enables MSP.  Use the no form of the <b>profile flow</b> command to disable MSP.
<b>Step 3</b>	end  <b>Example:</b> Switch(config)# end	Returns to privileged EXEC mode.

## Enabling Accounting Augmentation

For the Device Sensor protocol data to be added to accounting messages, you must first enable session accounting by using the following standard Authentication, Authorization, and Accounting (AAA) and RADIUS configuration commands:

```
Switch(config)# aaa new-model
Switch(config)# aaa accounting dot1x default start-stop group radius
Switch(config)# radius-server host{hostname|ip-address}[auth-port port-number][acct-port
port-number] [timeout seconds][retransmit retries][key string]
Switch(config)# radius-server vsa send accounting
```

To add Device Sensor protocol data to accounting records, follow these steps, beginning in privileged EXEC mode:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	configure terminal  <b>Example:</b> Switch# configure terminal	Enters global configuration mode.
<b>Step 2</b>	device-sensor accounting  <b>Example:</b> Switch(config)# device-sensor accounting	Enables the addition of sensor protocol data to accounting records and also enables the generation of additional accounting events when new sensor data is detected.
<b>Step 3</b>	end  <b>Example:</b> Switch(config)# end	Returns to privileged EXEC mode.

## Creating a Cisco Discovery Protocol Filter

To create a CDP filter containing a list of TLVs that can be included or excluded in the Device Sensor output, follow these steps, beginning in privileged EXEC mode:

```
configure terminal
```



**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Switch# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>device-sensor filter-list cdp list tlv-list-name</b>	

## Creating an LLDP Filter

To create an LLDP filter containing a list of TLVs that can be included or excluded in the Device Sensor output, follow these steps, beginning in privileged EXEC mode:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Switch# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>device-sensor filter-list lldp list tlv-list-name</b> <b>Example:</b> Switch(config)# device-sensor filter-list lldp list lldp-list	Creates a TLV list and enters LLDP sensor configuration mode, where you can configure individual TLVs.
<b>Step 3</b>	<b>tlv { name tlv-name   number tlv-number }</b> <b>Example:</b> Switch(config-sensor-cdplist)# tlv number 10	Adds individual LLDP TLVs to the TLV list. You can delete the TLV list without individually removing TLVs from the list by using the no device-sensor filter-list lldp list tlv-list-name command.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Switch(config-sensor-llldplist)# end	Returns to privileged EXEC mode.

## Creating a DHCP Filter

To create a DHCP filter containing a list of DHCP options that can be included or excluded in the Device Sensor output, follow these steps, beginning in privileged EXEC mode:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Switch# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>device-sensor filter-list dhcp list option-list-name</b> <b>Example:</b> device-sensor filter-list dhcp list option-list-name	Creates an options list and enters DHCP sensor configuration mode, where you can specify individual DHCP options.
<b>Step 3</b>	<b>option { name option-name   number option-number }</b> <b>Example:</b> Switch(config-sensor-dhcplist)# option number 50	Adds individual DHCP options to the option list. You can delete the entire option list without removing options individually from the list by using the no device-sensor filter-list dhcp list option-list-name command.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Switch(config)# end	Returns to privileged EXEC mode.

## Applying a Protocol Filter to the Device Sensor Output

Beginning in privileged EXEC mode, follow these steps to apply a CDP, LLDP, or DHCP filter to the sensor output. The output is session notifications to internal sensor clients and accounting requests to the RADIUS server.



**Note** Only one filter list can be included or excluded at a time.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Switch# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>device-sensor filter-spec { cdp   dhcp   ldp } { exclude { all   list list-name }   include list list-name }</b> <b>Example:</b> Switch(config)# device-sensor filter-spec cdp include list list1	Applies a specific protocol filter containing a list of protocol TLV fields or DHCP options to the Device Sensor output. <ul style="list-style-type: none"> <li>• <b>cdp</b> –Applies a CDP TLV filter list to the device sensor output</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>lldp</b> –Applies an LLDP TLV filter list to the device sensor output.</li> <li>• <b>dhcp</b> –Applies a DHCP option filter list to the device sensor output.</li> <li>• <b>exclude</b> –Specifies the TLVs that must be excluded from the device sensor output.</li> <li>• <b>include</b> –Specifies the TLVs that must be included from the device sensor output.</li> <li>• <b>all</b> –Disables all notifications for the associated protocol.</li> <li>• <b>list list-name</b> –Specifies the protocol TLV filter list name.</li> </ul>
<b>Step 3</b>	<b>end</b>  <b>Example:</b> Switch(config)# end	Returns to privileged EXEC mode.

## Tracking TLV Changes

By default, client notifications and accounting events are generated only when an incoming packet includes a TLV that has not previously been received within a given session.

To enable client notifications and accounting events for TLV changes, follow these steps, beginning in privileged EXEC mode:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Switch# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>device-sensor notify all-changes</b>  <b>Example:</b> Switch(config)# device-sensor notify all-changes	<p>Enables client notifications and accounting events for all TLV changes, that is, where either a new TLV is received or a previously received TLV is received with a new value in the context of a given session.</p> <p>Note Use the default device-sensor notify or the device-sensor notify new-tlvs command to return to the default TLV.</p>
<b>Step 3</b>	<b>end</b>  <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	Switch(config)# end	

## Verifying the Device Sensor Configuration

To verify the sensor cache entries for all devices, follow these steps, beginning in privileged EXEC mode:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>show device-sensor cache mac mac-address</b>	Displays sensor cache entries (the list of protocol TLVs or options received from a device) for a specific device. <ul style="list-style-type: none"> <li>• mac-address is the MAC address of the endpoint</li> </ul>
<b>Step 2</b>	<b>show device-sensor cache all</b>  <b>Example:</b> Switch(config)# device-sensor notify all-changes	Displays sensor cache entries for all devices.

## Troubleshooting Commands

The following commands can help troubleshoot Device Sensor.

- `debug device-sensor { errors | events }`
- `debug authentication all`

## Restrictions for Device Sensor

- Only CDP, LLDP, and DHCP protocols are supported.
- The session limit for profiling ports is 32.
- The length of one TLV must not be more than 1024 and the total length of TLVs (combined length of TLVs) of all protocols must not be more than 4096.
- Device Sensor profiles devices that are only one hop away.

## Configuration Examples for the Device Sensor Feature

The following example shows how to create a CDP filter containing a list of TLVs:

```
Switch> enable
Switch# configure terminal
```

```
Switch(config)# device-sensor filter-list cdp list cdp-list
Switch(config-sensor-cdplist)# tlv name address-type
Switch(config-sensor-cdplist)# tlv name device-name
Switch(config-sensor-cdplist)# tlv number 34
Switch(config-sensor-cdplist)# end
```

The following example shows how to create an LLDP filter containing a list of TLVs:

```
Switch> enable
Switch# configure terminal
Switch(config)# device-sensor filter-list lldp list lldp-list
Switch(config-sensor-lddplist)# tlv name chassis-id
Switch(config-sensor-lddplist)# tlv name management-address
Switch(config-sensor-lddplist)# tlv number 28
Switch(config-sensor-lddplist)# end
```

The following example shows how to create a DHCP filter containing a list of options:

```
Switch> enable
Switch# configure terminal
Switch(config)# device-sensor filter-list dhcp list dhcp-list
Switch(config)# device-sensor filter-list dhcp list dhcp-list
Switch(config-sensor-dhcplist)# option name domain-name
Switch(config-sensor-dhcplist)# option name host-name
Switch(config-sensor-dhcplist)# option number 50
Switch(config-sensor-dhcplist)# end
```

The following example shows how to apply a CDP TLV filter list to the Device Sensor output:

```
Switch> enable
Switch# configure terminal
Switch(config)# device-sensor filter-spec cdp include cdp-list1
```

The following example shows how to enable client notifications and accounting events for all TLV changes:

```
Switch> enable
Switch# configure terminal
Switch(config)# device-sensor notify all-changes
```

## Feature Information for Device Sensor

*Table 156: Feature Information for Device Sensor*

Feature Name	Releases	Feature Information
Device Sensor	Cisco IOS XE 3.6E	This feature was introduced.





## CHAPTER 112

# Web-Based Authentication

---

This chapter describes how to configure web-based authentication on the device. It contains these sections:

- [Finding Feature Information, on page 2089](#)
- [Web-Based Authentication Overview, on page 2089](#)
- [How to Configure Web-Based Authentication, on page 2098](#)
- [Verifying Web-Based Authentication Status, on page 2110](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Web-Based Authentication Overview

Use the web-based authentication feature, known as web authentication proxy, to authenticate end users on host systems that do not run the IEEE 802.1x supplicant.

When you initiate an HTTP session, web-based authentication intercepts ingress HTTP packets from the host and sends an HTML login page to the users. The users enter their credentials, which the web-based authentication feature sends to the authentication, authorization, and accounting (AAA) server for authentication.

If authentication succeeds, web-based authentication sends a Login-Successful HTML page to the host and applies the access policies returned by the AAA server.

If authentication fails, web-based authentication forwards a Login-Fail HTML page to the user, prompting the user to retry the login. If the user exceeds the maximum number of attempts, web-based authentication forwards a Login-Expired HTML page to the host, and the user is placed on a watch list for a waiting period.



---

**Note** HTTPS traffic interception for central web authentication redirect is not supported.

---




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**Note** You should use global parameter-map (for method-type, custom, and redirect) only for using the same web authentication methods like consent, web consent, and webauth, for all the clients and SSIDs. This ensures that all the clients have the same web-authentication method.

If the requirement is to use Consent for one SSID and Web-authentication for another SSID, then you should use two named parameter-maps. You should configure Consent in first parameter-map and configure webauth in second parameter-map.

---




---

**Note** The traceback that you receive when webauth client tries to do authentication does not have any performance or behavioral impact. It happens rarely when the context for which FFM replied back to EPM for ACL application is already dequeued (possibly due to timer expiry) and the session becomes 'unauthorized'.

---

Based on where the web pages are hosted, the local web authentication can be categorized as follows:

- *Internal*—The internal default HTML pages (Login, Success, Fail, and Expire) in the controller are used during the local web authentication.
- *Customized*—The customized web pages (Login, Success, Fail, and Expire) are downloaded onto the controller and used during the local web authentication.
- *External*—The customized web pages are hosted on the external web server instead of using the in-built or custom web pages.

Based on the various web authentication pages, the types of web authentication are as follows:

- *Webauth*—This is a basic web authentication. Herein, the controller presents a policy page with the user name and password. You need to enter the correct credentials to access the network.
- *Consent or web-passthrough*—Herein, the controller presents a policy page with the Accept or Deny buttons. You need to click the Accept button to access the network.
- *Webconsent*—This is a combination of webauth and consent web authentication types. Herein, the controller presents a policy page with Accept or Deny buttons along with user name or password. You need to enter the correct credentials and click the Accept button to access the network.

## Device Roles

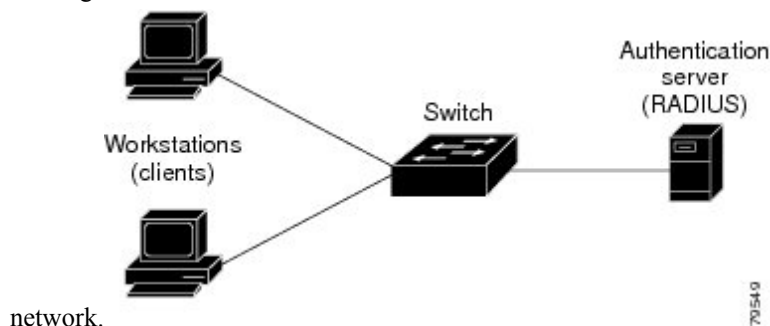
With web-based authentication, the devices in the network have these specific roles:

- *Client*—The device (workstation) that requests access to the LAN and the services and responds to requests from the switch. The workstation must be running an HTML browser with Java Script enabled.
- *Authentication server*—Authenticates the client. The authentication server validates the identity of the client and notifies the switch that the client is authorized to access the LAN and the switch services or that the client is denied.
- *Switch*—Controls the physical access to the network based on the authentication status of the client. The switch acts as an intermediary (proxy) between the client and the authentication server, requesting identity information from the client, verifying that information with the authentication server, and relaying a response to the client.



**Figure 133: Web-Based Authentication Device Roles**

This figure shows the roles of these devices in a



## Host Detection

The switch maintains an IP device tracking table to store information about detected hosts.



**Note** By default, the IP device tracking feature is disabled on a switch. You must enable the IP device tracking feature to use web-based authentication.

For Layer 2 interfaces, web-based authentication detects IP hosts by using these mechanisms:

- ARP based trigger—ARP redirect ACL allows web-based authentication to detect hosts with a static IP address or a dynamic IP address.
- Dynamic ARP inspection
- DHCP snooping—Web-based authentication is notified when the switch creates a DHCP-binding entry for the host.

## Session Creation

When web-based authentication detects a new host, it creates a session as follows:

- Reviews the exception list.  
If the host IP is included in the exception list, the policy from the exception list entry is applied, and the session is established.
- Reviews for authorization bypass  
If the host IP is not on the exception list, web-based authentication sends a nonresponsive-host (NRH) request to the server.  
If the server response is access accepted, authorization is bypassed for this host. The session is established.
- Sets up the HTTP intercept ACL  
If the server response to the NRH request is access rejected, the HTTP intercept ACL is activated, and the session waits for HTTP traffic from the host.

## Authentication Process

When you enable web-based authentication, these events occur:

- The user initiates an HTTP session.
- The HTTP traffic is intercepted, and authorization is initiated. The switch sends the login page to the user. The user enters a username and password, and the switch sends the entries to the authentication server.
- If the authentication succeeds, the switch downloads and activates the user's access policy from the authentication server. The login success page is sent to the user.
- If the authentication fails, the switch sends the login fail page. The user retries the login. If the maximum number of attempts fails, the switch sends the login expired page, and the host is placed in a watch list. After the watch list times out, the user can retry the authentication process.
- If the authentication server does not respond to the switch, and if an AAA fail policy is configured, the switch applies the failure access policy to the host. The login success page is sent to the user.
- The switch reauthenticates a client when the host does not respond to an ARP probe on a Layer 2 interface, or when the host does not send any traffic within the idle timeout on a Layer 3 interface.
- The switch reauthenticates a client when the host does not respond to an ARP probe on a Layer 2 interface.
- The feature applies the downloaded timeout or the locally configured session timeout.
- If the terminate action is RADIUS, the feature sends a nonresponsive host (NRH) request to the server. The terminate action is included in the response from the server.
- If the terminate action is default, the session is dismantled, and the applied policy is removed.

## Local Web Authentication Banner

With Web Authentication, you can create a default and customized web-browser banners that appears when you log in to a switch.

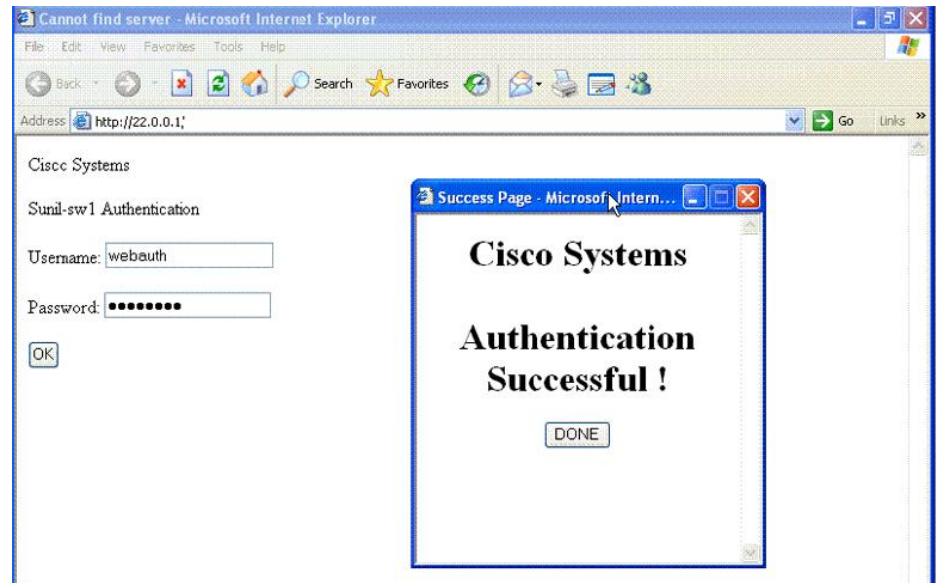
The banner appears on both the login page and the authentication-result pop-up pages. The default banner messages are as follows:

- *Authentication Successful*
- *Authentication Failed*
- *Authentication Expired*

The Local Web Authentication Banner can be configured in legacy and new-style (Session-aware) CLIs as follows:

- Legacy mode—Use the **ip admission auth-proxy-banner http** global configuration command.
- New-style mode—Use the **parameter-map type webauth global banner** global configuration command.

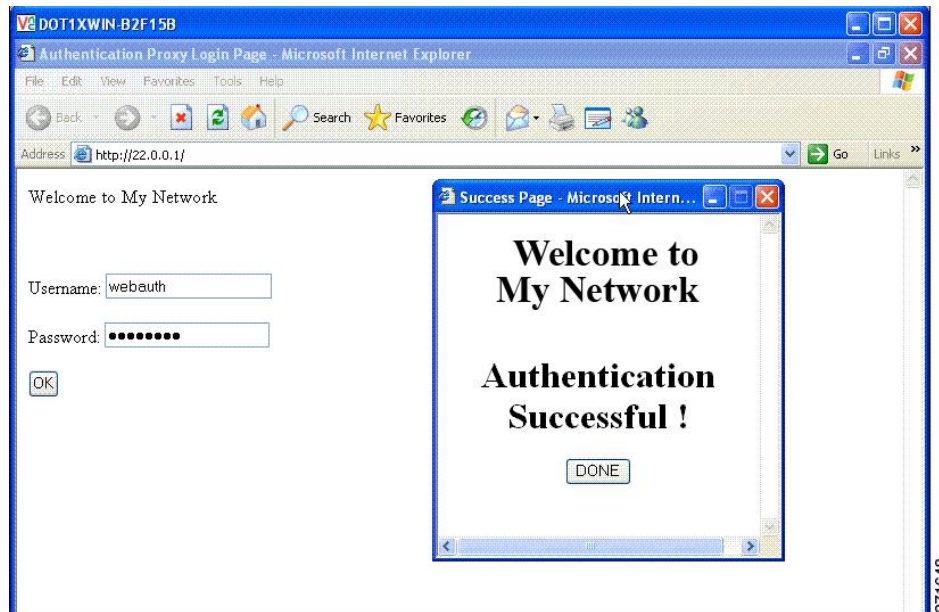
The default banner *Cisco Systems* and *Switch host-name Authentication* appear on the Login Page. *Cisco Systems* appears on the authentication result pop-up page.

**Figure 134: Authentication Successful Banner**

The banner can be customized as follows:

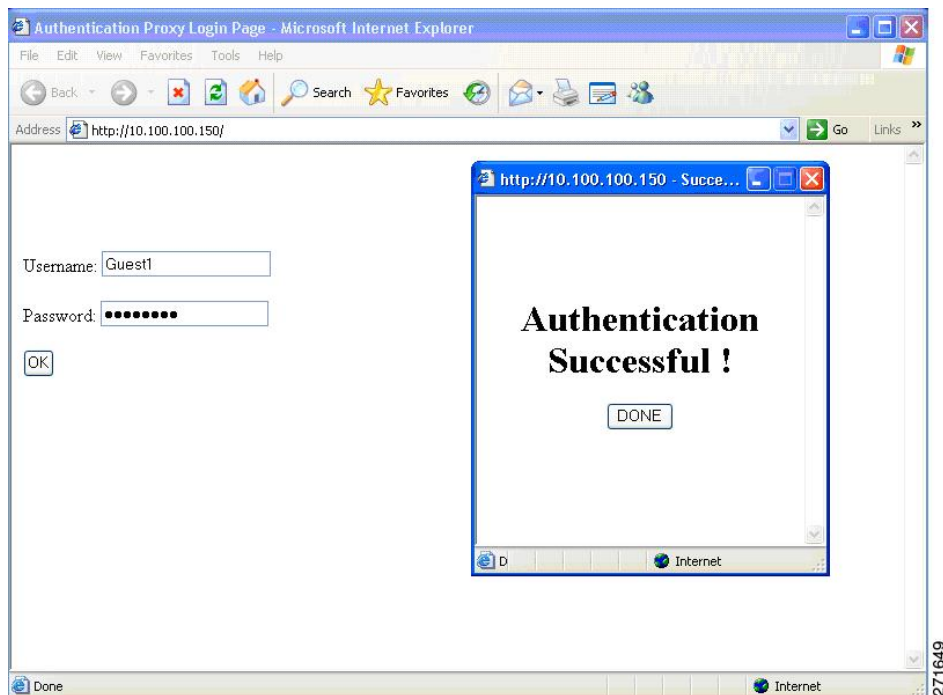
- Add a message, such as switch, router, or company name to the banner:
  - Legacy mode—Use the **ip admission auth-proxy-banner http banner-text** global configuration command.
  - New-style mode—Use the **parameter-map type webauth global banner** global configuration command.
- Add a logo or text file to the banner:
  - Legacy mode—Use the **ip admission auth-proxy-banner http file-path** global configuration command.
  - New-style mode—Use the **parameter-map type webauth global banner** global configuration command.

Figure 135: Customized Web Banner



If you do not enable a banner, only the username and password dialog boxes appear in the web authentication login screen, and no banner appears when you log into the switch.

Figure 136: Login Screen With No Banner



For more information, see the *Session Aware Networking Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)* *Session Aware Networking Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)* and the *Web Authentication Enhancements - Customizing Authentication Proxy Web Pages*.

## Web Authentication Customizable Web Pages

During the web-based authentication process, the switch internal HTTP server hosts four HTML pages to deliver to an authenticating client. The server uses these pages to notify you of these four-authentication process states:

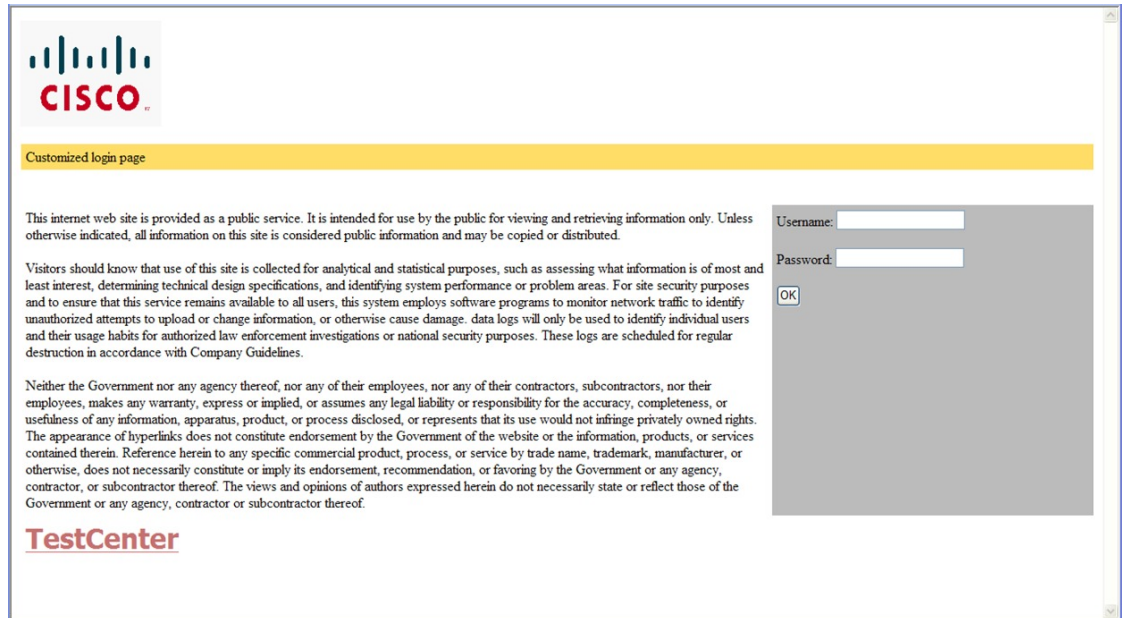
- Login—Your credentials are requested.
- Success—The login was successful.
- Fail—The login failed.
- Expire—The login session has expired because of excessive login failures.

### Guidelines

- You can substitute your own HTML pages for the default internal HTML pages.
- You can use a logo or specify text in the *login*, *success*, *failure*, and *expire* web pages.
- On the banner page, you can specify text in the login page.
- The pages are in HTML.
- You must include an HTML redirect command in the success page to access a specific URL.
- The URL string must be a valid URL (for example, <http://www.cisco.com>). An incomplete URL might cause *page not found* or similar errors on a web browser.
- If you configure web pages for HTTP authentication, they must include the appropriate HTML commands (for example, to set the page time out, to set a hidden password, or to confirm that the same page is not submitted twice).
- The CLI command to redirect users to a specific URL is not available when the configured login form is enabled. The administrator should ensure that the redirection is configured in the web page.
- If the CLI command redirecting users to specific URL after authentication occurs is entered and then the command configuring web pages is entered, the CLI command redirecting users to a specific URL does not take effect.
- Configured web pages can be copied to the switch boot flash or flash.
- The login page can be on one flash, and the success and failure pages can be another flash (for example, the flash on the stack master or a member).
- You must configure all four pages.
- The banner page has no effect if it is configured with the web page.
- All of the logo files (image, flash, audio, video, and so on) that are stored in the system directory (for example, flash, disk0, or disk) and that must be displayed on the login page must use `web_auth_<filename>` as the file name.
- The configured authentication proxy feature supports both HTTP and SSL.

You can substitute your HTML pages for the default internal HTML pages. You can also specify a URL to which users are redirected after authentication occurs, which replaces the internal Success page.

Figure 137: Customizable Authentication Page



## Authentication Proxy Web Page Guidelines

When configuring customized authentication proxy web pages, follow these guidelines:

- To enable the custom web pages feature, specify all four custom HTML files. If you specify fewer than four files, the internal default HTML pages are used.
- The four custom HTML files must be present on the flash memory of the switch. The maximum size of each HTML file is 8 KB.
- Any images on the custom pages must be on an accessible HTTP server. Configure an intercept ACL within the admission rule.
- Any external link from a custom page requires configuration of an intercept ACL within the admission rule.
- To access a valid DNS server, any name resolution required for external links or images requires configuration of an intercept ACL within the admission rule.
- If the custom web pages feature is enabled, a configured auth-proxy-banner is not used.
- If the custom web pages feature is enabled, the redirection URL for successful login feature is not available.
- To remove the specification of a custom file, use the **no** form of the command.

Because the custom login page is a public web form, consider these guidelines for the page:

- The login form must accept user entries for the username and password and must show them as **uname** and **pwd**.
- The custom login page should follow best practices for a web form, such as page timeout, hidden password, and prevention of redundant submissions.

**Related Topics**

[Customizing the Authentication Proxy Web Pages](#), on page 2106

## Redirection URL for Successful Login Guidelines

When configuring a redirection URL for successful login, consider these guidelines:

- If the custom authentication proxy web pages feature is enabled, the redirection URL feature is disabled and is not available in the CLI. You can perform redirection in the custom-login success page.
- If the redirection URL feature is enabled, a configured auth-proxy-banner is not used
- To remove the specification of a redirection URL, use the **no** form of the command.
- If the redirection URL is required after the web-based authentication client is successfully authenticated, then the URL string must start with a valid URL (for example, http://) followed by the URL information. If only the URL is given without http://, then the redirection URL on successful authentication might cause page not found or similar errors on a web browser.

**Related Topics**

[Specifying a Redirection URL for Successful Login](#), on page 2107

## Web-based Authentication Interactions with Other Features

### Port Security

You can configure web-based authentication and port security on the same port. Web-based authentication authenticates the port, and port security manages network access for all MAC addresses, including that of the client. You can then limit the number or group of clients that can access the network through the port.

**Related Topics**

[Enabling and Configuring Port Security](#), on page 2128

### LAN Port IP

You can configure LAN port IP (LPIP) and Layer 2 web-based authentication on the same port. The host is authenticated by using web-based authentication first, followed by LPIP posture validation. The LPIP host policy overrides the web-based authentication host policy.

If the web-based authentication idle timer expires, the NAC policy is removed. The host is authenticated, and posture is validated again.

### Gateway IP

You cannot configure Gateway IP (GWIP) on a Layer 3 VLAN interface if web-based authentication is configured on any of the switch ports in the VLAN.

You can configure web-based authentication on the same Layer 3 interface as Gateway IP. The host policies for both features are applied in software. The GWIP policy overrides the web-based authentication host policy.

### ACLs

If you configure a VLAN ACL or a Cisco IOS ACL on an interface, the ACL is applied to the host traffic only after the web-based authentication host policy is applied.

For Layer 2 web-based authentication, it is more secure, though not required, to configure a port ACL (PACL) as the default access policy for ingress traffic from hosts connected to the port. After authentication, the web-based authentication host policy overrides the PACL. The Policy ACL is applied to the session even if there is no ACL configured on the port.

You cannot configure a MAC ACL and web-based authentication on the same interface.

You cannot configure web-based authentication on a port whose access VLAN is configured for VACL capture.

## Context-Based Access Control

Web-based authentication cannot be configured on a Layer 2 port if context-based access control (CBAC) is configured on the Layer 3 VLAN interface of the port VLAN.

## EtherChannel

You can configure web-based authentication on a Layer 2 EtherChannel interface. The web-based authentication configuration applies to all member channels.

# How to Configure Web-Based Authentication

## Default Web-Based Authentication Configuration

The following table shows the default web-based authentication configuration.

**Table 157: Default Web-based Authentication Configuration**

Feature	Default Setting
AAA	Disabled
RADIUS server <ul style="list-style-type: none"> <li>• IP address</li> <li>• UDP authentication port</li> <li>• Key</li> </ul>	<ul style="list-style-type: none"> <li>• None specified</li> <li>• 1645</li> <li>• None specified</li> </ul>
Default value of inactivity timeout	3600 seconds
Inactivity timeout	Enabled

## Web-Based Authentication Configuration Guidelines and Restrictions

- Web-based authentication is an ingress-only feature.
- You can configure web-based authentication only on access ports. Web-based authentication is not supported on trunk ports, EtherChannel member ports, or dynamic trunk ports.



- External web authentication, where the switch redirects a client to a particular host or web server for displaying login message, is not supported.
- You cannot authenticate hosts on Layer 2 interfaces with static ARP cache assignment. These hosts are not detected by the web-based authentication feature because they do not send ARP messages.
- By default, the IP device tracking feature is disabled on a switch. You must enable the IP device tracking feature to use web-based authentication.
- You must enable SISF-Based device tracking to use web-based authentication. By default, SISF-Based device tracking is disabled on a switch.
- You must configure at least one IP address to run the switch HTTP server. You must also configure routes to reach each host IP address. The HTTP server sends the HTTP login page to the host.
- Hosts that are more than one hop away might experience traffic disruption if an STP topology change results in the host traffic arriving on a different port. This occurs because the ARP and DHCP updates might not be sent after a Layer 2 (STP) topology change.
- Web-based authentication does not support VLAN assignment as a downloadable-host policy.
- Web-based authentication supports IPv6 in Session-aware policy mode. IPv6 Web-authentication requires at least one IPv6 address configured on the switch and IPv6 Snooping configured on the switchport.
- Web-based authentication and Network Edge Access Topology (NEAT) are mutually exclusive. You cannot use web-based authentication when NEAT is enabled on an interface, and you cannot use NEAT when web-based authentication is running on an interface.
- Identify the following RADIUS security server settings that will be used while configuring switch-to-RADIUS-server communication:
  - Host name
  - Host IP address
  - Host name and specific UDP port numbers
  - IP address and specific UDP port numbers

The combination of the IP address and UDP port number creates a unique identifier, that enables RADIUS requests to be sent to multiple UDP ports on a server at the same IP address. If two different host entries on the same RADIUS server are configured for the same service (for example, authentication) the second host entry that is configured functions as the failover backup to the first one. The RADIUS host entries are chosen in the order that they were configured.

- When you configure the RADIUS server parameters:
  - Specify the **key string** on a separate command line.
  - For **key string**, specify the authentication and encryption key used between the switch and the RADIUS daemon running on the RADIUS server. The key is a text string that must match the encryption key used on the RADIUS server.
  - When you specify the **key string**, use spaces within and at the end of the key. If you use spaces in the key, do not enclose the key in quotation marks unless the quotation marks are part of the key. This key must match the encryption used on the RADIUS daemon.

- You can globally configure the timeout, retransmission, and encryption key values for all RADIUS servers by using with the **radius-server host** global configuration command. If you want to configure these options on a per-server basis, use the **radius-server timeout**, **radius-server transmit**, and the **radius-server key** global configuration commands.



**Note** You need to configure some settings on the RADIUS server, including: the switch IP address, the key string to be shared by both the server and the switch, and the downloadable ACL (DACL). For more information, see the RADIUS server documentation.

## Configuring the Authentication Rule and Interfaces

Follow these steps to configure the authentication rule and interfaces:

### Before you begin

SISF-Based device tracking is a prerequisite to Web Authentication. Ensure that you have enabled device tracking programmatically or manually.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip admission name <i>name</i> proxy http</b> <b>Example:</b> Device(config)# <b>ip admission name webauth1 proxy http</b>	Configures an authentication rule for web-based authorization.
<b>Step 4</b>	<b>interface <i>type slot/port</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/1</b>	Enters interface configuration mode and specifies the ingress Layer 2 or Layer 3 interface to be enabled for web-based authentication.

	Command or Action	Purpose
		<i>type</i> can be fastethernet, gigabit ethernet, or tengigabitethernet.
<b>Step 5</b>	<b>ip access-group</b> <i>name</i> <b>Example:</b>  Device(config-if)# <b>ip access-group webauthag</b>	Applies the default ACL.
<b>Step 6</b>	<b>ip admission</b> <i>name</i> <b>Example:</b>  Device(config)# <b>ip admission name</b>	Configures an authentication rule for web-based authorization for the interface.
<b>Step 7</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show ip admission</b> <b>Example:</b>  Device# <b>show ip admission</b>	Displays the configuration.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring AAA Authentication

If a method-list is configured under VTY lines, the corresponding method list must be added to the AAA configuration:

```
line vty 0 4
  authorization commands 15 abc
aaa authorization commands 15 abc group tacacs+
```

If a method-list is not configured under VTY lines, you must add the default method list to the AAA configuration:

```
line vty 0 4
  aaa authorization commands 15 default group tacacs+
```

Follow these steps to configure AAA authentication:



**Note** Use default list for AAA authorization, if you are planning to use features such as dACL.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>aaa new-model</b> <b>Example:</b> Device (config)# <b>aaa new-model</b>	Enables AAA functionality.
<b>Step 4</b>	<b>aaa authentication login default group {tacacs+   radius}</b> <b>Example:</b> Device (config)# <b>aaa authentication login default group tacacs+</b>	Defines the list of authentication methods at login.  <b>named_authentication_list</b> refers to any name that is not greater than 31 characters.  <b>AAA_group_name</b> refers to the server group name. You need to define the server-group <b>server_name</b> at the beginning itself.
<b>Step 5</b>	<b>aaa authorization auth-proxy default group {tacacs+   radius}</b> <b>Example:</b> Device (config)# <b>aaa authorization auth-proxy default group tacacs+</b>	Creates an authorization method list for web-based authorization.
<b>Step 6</b>	<b>tacacs server server-name</b> <b>Example:</b> Device (config)# <b>tacacs server yourserver</b>	Specifies an AAA server.

	Command or Action	Purpose
<b>Step 7</b>	<b>address</b> { <i>ipv4</i>   <i>ipv6</i> } <i>ip address</i> <b>Example:</b> Device (config-server-tacacs) # <b>address</b> <b>ipv4 10.0.1.12</b>	Configures the IP address for the TACACS server.
<b>Step 8</b>	<b>key string</b> <b>Example:</b> Device (config-server-tacacs) # <b>key</b> <b>cisco123</b>	Configures the authorization and encryption key used between the switch and the TACACS server.
<b>Step 9</b>	<b>exit</b> <b>Example:</b> Device (config-server-tacacs) # <b>exit</b>	Exits the TACACS server mode and enters the global configuration mode.
<b>Step 10</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 11</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 12</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

## Configuring Switch-to-RADIUS-Server Communication

Follow these steps to configure the RADIUS server parameters:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>	Enables privileged EXEC mode.

	Command or Action	Purpose
	<b>Example:</b>  Device> <b>enable</b>	<ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip radius source-interface vlan <i>vlan interface number</i></b>  <b>Example:</b>  Device(config)# <b>ip radius source-interface vlan 80</b>	Specifies that the RADIUS packets have the IP address of the indicated interface.
<b>Step 4</b>	<b>radius server <i>server name</i></b>  <b>Example:</b>  Device(config)# <b>radius server rsim address ipv4 124.2.2.12</b>	(Optional) Specifies the IP address of the RADIUS server.
<b>Step 5</b>	<b>address {<i>ipv4   ipv6</i>} <i>ip address</i></b>  <b>Example:</b>  Device(config-radius-server)# <b>address ipv4 10.0.1.2 auth-port 1550 acct-port 1560</b>	Configures the IP address for the RADIUS server.
<b>Step 6</b>	<b>key <i>string</i></b>  <b>Example:</b>  Device(config-radius-server)# <b>key rad123</b>	(Optional) Specifies the authentication and encryption key used between the switch and the RADIUS daemon running on the RADIUS server.
<b>Step 7</b>	<b>exit</b>  <b>Example:</b>  Device(config-radius-server)# <b>exit</b>	Exits the RADIUS server mode and enters the global configuration mode.
<b>Step 8</b>	<b>radius-server dead-criteria tries <i>num-tries</i></b>  <b>Example:</b>	Specifies the number of unanswered sent messages to a RADIUS server before considering the server to be inactive. The range of <i>num-tries</i> is 1 to 100.

	Command or Action	Purpose
	Device(config)# <b>radius-server dead-criteria tries 30</b>	
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Configuring the HTTP Server

To use web-based authentication, you must enable the HTTP server within the Device. You can enable the server for either HTTP or HTTPS.



**Note** The Apple psuedo-browser will not open if you configure only the **ip http secure-server** command. You should also configure the **ip http server** command.

Follow the procedure given below to enable the server for either HTTP or HTTPS:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip http server</b> <b>Example:</b> Device(config)# <b>ip http server</b>	Enables the HTTP server. The web-based authentication feature uses the HTTP server to communicate with the hosts for user authentication.
<b>Step 4</b>	<b>ip http secure-server</b> <b>Example:</b>	Enables HTTPS. You can configure custom authentication proxy web pages or specify a redirection URL for successful login.

	Command or Action	Purpose
	Device(config)# <b>ip http secure-server</b>	<b>Note</b> To ensure secure authentication when you enter the <b>ip http secure-server</b> command, the login page is always in HTTPS (secure HTTP) even if the user sends an HTTP request.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Customizing the Authentication Proxy Web Pages

You can configure web authentication to display four substitute HTML pages to the user in place of the Device default HTML pages during web-based authentication.

For the equivalent Session Aware Networking configuration example for this feature, see the section "Configuring a Parameter Map for Web-Based Authentication" in the chapter, "Configuring Identity Control Policies." of the book, "*Session Aware Networking Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)*."

Follow these steps to specify the use of your custom authentication proxy web pages:

### Before you begin

Store your custom HTML files on the Device flash memory.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip admission proxy http login page file</b> <i>device:login-filename</i> <b>Example:</b> Device(config)# <b>ip admission proxy http</b>	Specifies the location in the Device memory file system of the custom HTML file to use in place of the default login page. The <i>device:</i> is flash memory.



	Command or Action	Purpose
	<code>login page file disk1:login.htm</code>	
<b>Step 4</b>	<p><b>ip admission proxy http success page file</b> <i>device:success-filename</i></p> <p><b>Example:</b></p> <pre>Device(config)# ip admission proxy http success page file disk1:success.htm</pre>	Specifies the location of the custom HTML file to use in place of the default login success page.
<b>Step 5</b>	<p><b>ip admission proxy http failure page file</b> <i>device:fail-filename</i></p> <p><b>Example:</b></p> <pre>Device(config)# ip admission proxy http fail page file disk1:fail.htm</pre>	Specifies the location of the custom HTML file to use in place of the default login failure page.
<b>Step 6</b>	<p><b>ip admission proxy http login expired page file</b> <i>device:expired-filename</i></p> <p><b>Example:</b></p> <pre>Device(config)# ip admission proxy http login expired page file disk1:expired.htm</pre>	Specifies the location of the custom HTML file to use in place of the default login expired page.
<b>Step 7</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.

**Related Topics**

[Authentication Proxy Web Page Guidelines](#), on page 2096

**Specifying a Redirection URL for Successful Login**

Follow these steps to specify a URL to which the user is redirected after authentication, effectively replacing the internal Success HTML page:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
	Device> <b>enable</b>	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip admission proxy http success redirect</b> <i>url-string</i> <b>Example:</b> Device(config)# <b>ip admission proxy http</b> <b>success redirect www.example.com</b>	Specifies a URL for redirection of the user in place of the default login success page.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

**Related Topics**

[Redirection URL for Successful Login Guidelines](#), on page 2097

## Configuring Web-Based Authentication Parameters

Follow these steps to configure the maximum number of failed login attempts before the client is placed in a watch list for a waiting period:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>ip admission max-login-attempts</b> <i>number</i> <b>Example:</b> Device(config)# <b>ip admission max-login-attempts 10</b>	Sets the maximum number of failed login attempts. The range is 1 to 2147483647 attempts. The default is 5.
<b>Step 4</b>	<b>exit</b> <b>Example:</b> Device# <b>exit</b>	Exits global configuration mode and returns to privileged EXEC mode.

## Configuring a Web-Based Authentication Local Banner

Follow these steps to configure a local banner on a switch that has web authentication configured.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>ip admission auth-proxy-banner http</b> <i>[banner-text   file-path]</i> <b>Example:</b> Device(config)# <b>ip admission auth-proxy-banner http C My Switch C</b>	Enables the local banner. (Optional) Create a custom banner by entering <i>C banner-text C</i> (where <i>C</i> is a delimiting character), or <i>file-path</i> that indicates a file (for example, a logo or text file) that appears in the banner.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 5</b>	<b>show running-config</b> <b>Example:</b> Device# <code>show running-config</code>	Verifies your entries.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Removing Web-Based Authentication Cache Entries

Follow these steps to remove web-based authentication cache entries:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>clear ip auth-proxy cache</b> <i>{* host ip address}</i> <b>Example:</b> Device# <code>clear ip auth-proxy cache 192.168.4.5</code>	Delete authentication proxy entries. Use an asterisk to delete all cache entries. Enter a specific IP address to delete the entry for a single host.
<b>Step 3</b>	<b>clear ip admission cache</b> <i>{* host ip address}</i> <b>Example:</b> Device# <code>clear ip admission cache 192.168.4.5</code>	Delete authentication proxy entries. Use an asterisk to delete all cache entries. Enter a specific IP address to delete the entry for a single host.

## Verifying Web-Based Authentication Status

Use the commands in this topic to display the web-based authentication settings for all interfaces or for specific ports.

Table 158: Privileged EXEC show Commands

Command	Purpose
<b>show authentication sessions method webauth</b>	Displays the web-based authentication settings for all interfaces for fastethernet, gigabitethernet, or tengigabitethernet
<b>show wireless client mac-address <i>a.a.a</i> detail</b>	Displays the session specific wireless information and wireless states.
<b>show authentication sessions interface <i>type slot/port</i>[details]</b>	Displays the web-based authentication settings for the specified interface for fastethernet, gigabitethernet, or tengigabitethernet.  In Session Aware Networking mode, use the <b>show access-session interface</b> command.





## CHAPTER 113

# Configuring Port-Based Traffic Control

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## Overview of Port-Based Traffic Control

Port-based traffic control is a set of Layer 2 features on the Cisco Catalyst switches used to filter or block packets at the port level in response to specific traffic conditions. The following port-based traffic control features are supported:

- Storm Control
- Protected Ports
- Port Blocking
- Port Security
- Protocol Storm Protection

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Storm Control

### Storm Control

Storm control prevents traffic on a LAN from being disrupted by a broadcast, multicast, or unicast storm on one of the physical interfaces. A LAN storm occurs when packets flood the LAN, creating excessive traffic and degrading network performance. Errors in the protocol-stack implementation, mistakes in network configurations, or users issuing a denial-of-service attack can cause a storm.

Storm control (or traffic suppression) monitors packets passing from an interface to the switching bus and determines if the packet is unicast, multicast, or broadcast. The switch counts the number of packets of a specified type received within the 1-second time interval and compares the measurement with a predefined suppression-level threshold.

### How Traffic Activity is Measured

Storm control uses one of these methods to measure traffic activity:

- Bandwidth as a percentage of the total available bandwidth of the port that can be used by the broadcast, multicast, or unicast traffic
- Traffic rate in packets per second at which broadcast, multicast, or unicast packets are received
- Traffic rate in bits per second at which broadcast, multicast, or unicast packets are received
- Traffic rate in packets per second and for small frames. This feature is enabled globally. The threshold for small frames is configured for each interface.

With each method, the port blocks traffic when the rising threshold is reached. The port remains blocked until the traffic rate drops below the falling threshold (if one is specified) and then resumes normal forwarding. If the falling suppression level is not specified, the switch blocks all traffic until the traffic rate drops below the rising suppression level. In general, the higher the level, the less effective the protection against broadcast storms.



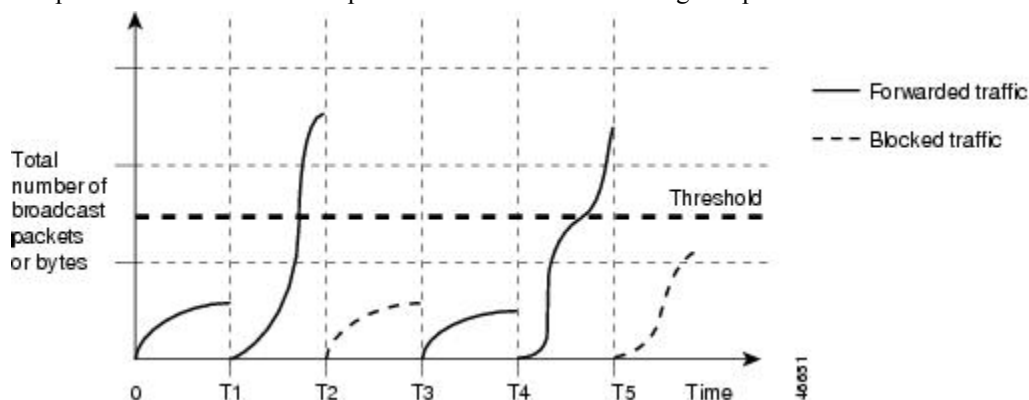


**Note** When the storm control threshold for multicast traffic is reached, all multicast traffic except control traffic, such as bridge protocol data unit (BDPU) and Cisco Discovery Protocol (CDP) frames, are blocked. However, the switch does not differentiate between routing updates, such as OSPF, and regular multicast data traffic, so both types of traffic are blocked.

## Traffic Patterns

**Figure 138: Broadcast Storm Control Example**

This example shows broadcast traffic patterns on an interface over a given period of time.



Broadcast traffic being forwarded exceeded the configured threshold between time intervals T1 and T2 and between T4 and T5. When the amount of specified traffic exceeds the threshold, all traffic of that kind is dropped for the next time period. Therefore, broadcast traffic is blocked during the intervals following T2 and T5. At the next time interval (for example, T3), if broadcast traffic does not exceed the threshold, it is again forwarded.

The combination of the storm-control suppression level and the 1-second time interval controls the way the storm control algorithm works. A higher threshold allows more packets to pass through. A threshold value of 100 percent means that no limit is placed on the traffic. A value of 0.0 means that all broadcast, multicast, or unicast traffic on that port is blocked.



**Note** Because packets do not arrive at uniform intervals, the 1-second time interval during which traffic activity is measured can affect the behavior of storm control.

You use the **storm-control** interface configuration commands to set the threshold value for each traffic type.

# How to Configure Storm Control

## Configuring Storm Control and Threshold Levels

You configure storm control on a port and enter the threshold level that you want to be used for a particular type of traffic.

However, because of hardware limitations and the way in which packets of different sizes are counted, threshold percentages are approximations. Depending on the sizes of the packets making up the incoming traffic, the actual enforced threshold might differ from the configured level by several percentage points.



**Note** Storm control is supported on physical interfaces. You can also configure storm control on an EtherChannel. When storm control is configured on an EtherChannel, the storm control settings propagate to the EtherChannel physical interfaces.

Follow these steps to storm control and threshold levels:

### Before you begin

Storm control is supported on physical interfaces. You can also configure storm control on an EtherChannel. When storm control is configured on an EtherChannel, the storm control settings propagate to the EtherChannel physical interfaces.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> Device(config)# <b>interface</b> <b>gigabitethernet1/0/1</b>	Specifies the interface to be configured, and enter interface configuration mode.
<b>Step 4</b>	<b>storm-control</b> { <b>broadcast</b>   <b>multicast</b>   <b>unicast</b> } <b>level</b> { <i>level</i> [ <i>level-low</i> ]   <b>bps</b> <i>bps</i> [ <i>bps-low</i> ]   <b>pps</b> <i>pps</i> [ <i>pps-low</i> ]}	Configures broadcast, multicast, or unicast storm control. By default, storm control is disabled.

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config-if)# storm-control unicast level 87 65</pre>	<p>The keywords have these meanings:</p> <ul style="list-style-type: none"> <li>• For <i>level</i>, specifies the rising threshold level for broadcast, multicast, or unicast traffic as a percentage (up to two decimal places) of the bandwidth. The port blocks traffic when the rising threshold is reached. The range is 0.00 to 100.00.</li> <li>• (Optional) For <i>level-low</i>, specifies the falling threshold level as a percentage (up to two decimal places) of the bandwidth. This value must be less than or equal to the rising suppression value. The port forwards traffic when traffic drops below this level. If you do not configure a falling suppression level, it is set to the rising suppression level. The range is 0.00 to 100.00.</li> </ul> <p>If you set the threshold to the maximum value (100 percent), no limit is placed on the traffic. If you set the threshold to 0.0, all broadcast, multicast, and unicast traffic on that port is blocked.</p> <ul style="list-style-type: none"> <li>• For <b>bps</b> <i>bps</i>, specifies the rising threshold level for broadcast, multicast, or unicast traffic in bits per second (up to one decimal place). The port blocks traffic when the rising threshold is reached. The range is 0.0 to 10000000000.0.</li> <li>• (Optional) For <i>bps-low</i>, specifies the falling threshold level in bits per second (up to one decimal place). It can be less than or equal to the rising threshold level. The port forwards traffic when traffic drops below this level. The range is 0.0 to 10000000000.0.</li> <li>• For <b>pps</b> <i>pps</i>, specifies the rising threshold level for broadcast, multicast, or unicast traffic in packets per second (up to one decimal place). The port blocks traffic when the rising threshold is reached. The range is 0.0 to 10000000000.0.</li> <li>• (Optional) For <i>pps-low</i>, specifies the falling threshold level in packets per second (up to one decimal place). It can be less than or equal to the rising threshold level. The port forwards traffic when</li> </ul>

	Command or Action	Purpose
		<p>traffic drops below this level. The range is <b>0.0 to 10000000000.0</b>.</p> <p>For BPS and PPS settings, you can use metric suffixes such as k, m, and g for large number thresholds.</p>
<b>Step 5</b>	<p><b>storm-control action {shutdown   trap}</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# storm-control action trap</pre>	<p>Specifies the action to be taken when a storm is detected. The default is to filter out the traffic and not to send traps.</p> <ul style="list-style-type: none"> <li>• Select the <b>shutdown</b> keyword to error-disable the port during a storm.</li> <li>• Select the <b>trap</b> keyword to generate an SNMP trap when a storm is detected.</li> </ul>
<b>Step 6</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.
<b>Step 7</b>	<p><b>show storm-control [interface-id] [broadcast   multicast   unicast]</b></p> <p><b>Example:</b></p> <pre>Device# show storm-control gigabitethernet1/0/1 unicast</pre>	Verifies the storm control suppression levels set on the interface for the specified traffic type. If you do not enter a traffic type, details for all traffic types (broadcast, multicast and unicast) are displayed.
<b>Step 8</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Information About Protected Ports

### Protected Ports

Some applications require that no traffic be forwarded at Layer 2 between ports on the same switch so that one neighbor does not see the traffic generated by another neighbor. In such an environment, the use of protected ports ensures that there is no exchange of unicast, broadcast, or multicast traffic between these ports on the switch.

Protected ports have these features:

- A protected port does not forward any traffic (unicast, multicast, or broadcast) to any other port that is also a protected port. Data traffic cannot be forwarded between protected ports at Layer 2; only control

traffic, such as PIM packets, is forwarded because these packets are processed by the CPU and forwarded in software. All data traffic passing between protected ports must be forwarded through a Layer 3 device.

- Forwarding behavior between a protected port and a nonprotected port proceeds as usual.

Because a switch stack represents a single logical switch, Layer 2 traffic is not forwarded between any protected ports in the switch stack, whether they are on the same or different switches in the stack.

## Default Protected Port Configuration

The default is to have no protected ports defined.

## Protected Ports Guidelines

You can configure protected ports on a physical interface (for example, Gigabit Ethernet port 1) or an EtherChannel group (for example, port-channel 5). When you enable protected ports for a port channel, it is enabled for all ports in the port-channel group.

# How to Configure Protected Ports

## Configuring a Protected Port

### Before you begin

Protected ports are not pre-defined. This is the task to configure one.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/1</b>	Specifies the interface to be configured, and enter interface configuration mode.

	Command or Action	Purpose
<b>Step 4</b>	<b>switchport protected</b> <b>Example:</b> Device (config-if) # <b>switchport protected</b>	Configures the interface to be a protected port.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show interfaces <i>interface-id</i> switchport</b> <b>Example:</b> Device# <b>show interfaces gigabitethernet 1/0/1 switchport</b>	Verifies your entries.
<b>Step 7</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Monitoring Protected Ports

Table 159: Commands for Displaying Protected Port Settings

Command	Purpose
<b>show interfaces [<i>interface-id</i>] switchport</b>	Displays the administrative and operational status of all switching (nonrouting) ports or the specified port, including port blocking and port protection settings.

# Information About Port Blocking

## Port Blocking

By default, the switch floods packets with unknown destination MAC addresses out of all ports. If unknown unicast and multicast traffic is forwarded to a protected port, there could be security issues. To prevent unknown unicast or multicast traffic from being forwarded from one port to another, you can block a port (protected or nonprotected) from flooding unknown unicast or multicast packets to other ports.



**Note** With multicast traffic, the port blocking feature blocks only pure Layer 2 packets. Multicast packets that contain IPv4 or IPv6 information in the header are not blocked.

## How to Configure Port Blocking

### Blocking Flooded Traffic on an Interface

#### Before you begin

The interface can be a physical interface or an EtherChannel group. When you block multicast or unicast traffic for a port channel, it is blocked on all ports in the port-channel group.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device (config)# <b>interface gigabitethernet 1/0/1</b>	Specifies the interface to be configured, and enter interface configuration mode.

	Command or Action	Purpose
<b>Step 4</b>	<b>switchport block multicast</b> <b>Example:</b> <pre>Device(config-if)# switchport block multicast</pre>	Blocks unknown multicast forwarding out of the port.
<b>Step 5</b>	<b>switchport block unicast</b> <b>Example:</b> <pre>Device(config-if)# switchport block unicast</pre>	Blocks unknown unicast forwarding out of the port.
<b>Step 6</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show interfaces <i>interface-id</i> switchport</b> <b>Example:</b> <pre>Device# show interfaces gigabitethernet 1/0/1 switchport</pre>	Verifies your entries.
<b>Step 8</b>	<b>show running-config</b> <b>Example:</b> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.



# Monitoring Port Blocking

Table 160: Commands for Displaying Port Blocking Settings

Command	Purpose
<code>show interfaces [interface-id] switchport</code>	Displays the administrative and operational status of all switching (nonrouting) ports or the specified port, including port blocking and port protection settings.

## Prerequisites for Port Security



**Note** If you try to set the maximum value to a number less than the number of secure addresses already configured on an interface, the command is rejected.

## Restrictions for Port Security

The maximum number of secure MAC addresses that you can configure on a switch or switch stack is set by the maximum number of available MAC addresses allowed in the system. This number is determined by the active Switch Database Management (SDM) template. This number is the total of available MAC addresses, including those used for other Layer 2 functions and any other secure MAC addresses configured on interfaces.

## Information About Port Security

### Port Security

You can use the port security feature to restrict input to an interface by limiting and identifying MAC addresses of the stations allowed to access the port. When you assign secure MAC addresses to a secure port, the port does not forward packets with source addresses outside the group of defined addresses. If you limit the number of secure MAC addresses to one and assign a single secure MAC address, the workstation attached to that port is assured the full bandwidth of the port.

If a port is configured as a secure port and the maximum number of secure MAC addresses is reached, when the MAC address of a station attempting to access the port is different from any of the identified secure MAC addresses, a security violation occurs. Also, if a station with a secure MAC address configured or learned on one secure port attempts to access another secure port, a violation is flagged.

#### Related Topics

[Enabling and Configuring Port Security](#), on page 2128

[Configuration Examples for Port Security](#), on page 2146

## Types of Secure MAC Addresses

The switch supports these types of secure MAC addresses:

- Static secure MAC addresses—These are manually configured by using the **switchport port-security mac-address *mac-address*** interface configuration command, stored in the address table, and added to the switch running configuration.
- Dynamic secure MAC addresses—These are dynamically configured, stored only in the address table, and removed when the switch restarts.
- Sticky secure MAC addresses—These can be dynamically learned or manually configured, stored in the address table, and added to the running configuration. If these addresses are saved in the configuration file, when the switch restarts, the interface does not need to dynamically reconfigure them.

## Sticky Secure MAC Addresses

You can configure an interface to convert the dynamic MAC addresses to sticky secure MAC addresses and to add them to the running configuration by enabling sticky learning. The interface converts all the dynamic secure MAC addresses, including those that were dynamically learned before sticky learning was enabled, to sticky secure MAC addresses. All sticky secure MAC addresses are added to the running configuration.

The sticky secure MAC addresses do not automatically become part of the configuration file, which is the startup configuration used each time the switch restarts. If you save the sticky secure MAC addresses in the configuration file, when the switch restarts, the interface does not need to relearn these addresses. If you do not save the sticky secure addresses, they are lost.

If sticky learning is disabled, the sticky secure MAC addresses are converted to dynamic secure addresses and are removed from the running configuration.

## Security Violations

It is a security violation when one of these situations occurs:

- The maximum number of secure MAC addresses have been added to the address table, and a station whose MAC address is not in the address table attempts to access the interface.
- An address learned or configured on one secure interface is seen on another secure interface in the same VLAN.
- Running diagnostic tests with port security enabled.

You can configure the interface for one of three violation modes, based on the action to be taken if a violation occurs:

- protect—when the number of secure MAC addresses reaches the maximum limit allowed on the port, packets with unknown source addresses are dropped until you remove a sufficient number of secure MAC addresses to drop below the maximum value or increase the number of maximum allowable addresses. You are not notified that a security violation has occurred.



**Note** We do not recommend configuring the protect violation mode on a trunk port. The protect mode disables learning when any VLAN reaches its maximum limit, even if the port has not reached its maximum limit.

- **restrict**—when the number of secure MAC addresses reaches the maximum limit allowed on the port, packets with unknown source addresses are dropped until you remove a sufficient number of secure MAC addresses to drop below the maximum value or increase the number of maximum allowable addresses. In this mode, you are notified that a security violation has occurred. An SNMP trap is sent, a syslog message is logged, and the violation counter increments.
- **shutdown**—a port security violation causes the interface to become error-disabled and to shut down immediately, and the port LED turns off. When a secure port is in the error-disabled state, you can bring it out of this state by entering the **errdisable recovery cause psecure-violation** global configuration command, or you can manually re-enable it by entering the **shutdown** and **no shut down** interface configuration commands. This is the default mode.
- **shutdown vlan**—Use to set the security violation mode per-VLAN. In this mode, the VLAN is error disabled instead of the entire port when a violation occurs

This table shows the violation mode and the actions taken when you configure an interface for port security.

**Table 161: Security Violation Mode Actions**

Violation Mode	Traffic is forwarded <a href="#">19</a>	Sends SNMP trap	Sends syslog message	Displays error message <a href="#">20</a>	Violation counter increments	Shuts down port
protect	No	No	No	No	No	No
restrict	No	Yes	Yes	No	Yes	No
shutdown	No	No	No	No	Yes	Yes
shutdown vlan	No	No	Yes	No	Yes	No <a href="#">21</a>

<sup>19</sup> Packets with unknown source addresses are dropped until you remove a sufficient number of secure MAC addresses.

<sup>20</sup> The switch returns an error message if you manually configure an address that would cause a security violation.

<sup>21</sup> Shuts down only the VLAN on which the violation occurred.

## Port Security Aging

You can use port security aging to set the aging time for all secure addresses on a port. Two types of aging are supported per port:

- **Absolute**—The secure addresses on the port are deleted after the specified aging time.

- Inactivity—The secure addresses on the port are deleted only if the secure addresses are inactive for the specified aging time.

### Related Topics

[Enabling and Configuring Port Security Aging](#), on page 2133

## Port Security and Switch Stacks

When a switch joins a stack, the new switch will get the configured secure addresses. All dynamic secure addresses are downloaded by the new stack member from the other stack members.

When a switch (either the active switch or a stack member) leaves the stack, the remaining stack members are notified, and the secure MAC addresses configured or learned by that switch are deleted from the secure MAC address table.

## Default Port Security Configuration

*Table 162: Default Port Security Configuration*

Feature	Default Setting
Port security	Disabled on a port.
Sticky address learning	Disabled.
Maximum number of secure MAC addresses per port	1.
Violation mode	Shutdown. The port shuts down when the maximum number of secure MAC addresses is exceeded.
Port security aging	Disabled. Aging time is 0. Static aging is disabled. Type is absolute.

## Port Security Configuration Guidelines

- Port security can only be configured on static access ports or trunk ports. A secure port cannot be a dynamic access port.
- A secure port cannot be a destination port for Switched Port Analyzer (SPAN).



**Note** Voice VLAN is only supported on access ports and not on trunk ports, even though the configuration is allowed.

- When you enable port security on an interface that is also configured with a voice VLAN, set the maximum allowed secure addresses on the port to two. When the port is connected to a Cisco IP phone, the IP phone requires one MAC address. The Cisco IP phone address is learned on the voice VLAN, but is not

learned on the access VLAN. If you connect a single PC to the Cisco IP phone, no additional MAC addresses are required. If you connect more than one PC to the Cisco IP phone, you must configure enough secure addresses to allow one for each PC and one for the phone.

- When a trunk port configured with port security and assigned to an access VLAN for data traffic and to a voice VLAN for voice traffic, entering the **switchport voice** and **switchport priority extend** interface configuration commands has no effect.

When a connected device uses the same MAC address to request an IP address for the access VLAN and then an IP address for the voice VLAN, only the access VLAN is assigned an IP address.

- When you enter a maximum secure address value for an interface, and the new value is greater than the previous value, the new value overwrites the previously configured value. If the new value is less than the previous value and the number of configured secure addresses on the interface exceeds the new value, the command is rejected.
- The switch does not support port security aging of sticky secure MAC addresses.

This table summarizes port security compatibility with other port-based features.

**Table 163: Port Security Compatibility with Other Switch Features**

Type of Port or Feature on Port	Compatible with Port Security
DTP <sup>22</sup> port <sup>23</sup>	No
Trunk port	Yes
Dynamic-access port <sup>24</sup>	No
Routed port	No
SPAN source port	Yes
SPAN destination port	No
EtherChannel	Yes
Tunneling port	Yes
Protected port	Yes
IEEE 802.1x port	Yes
Voice VLAN port <sup>25</sup>	Yes
IP source guard	Yes
Dynamic Address Resolution Protocol (ARP) inspection	Yes
Flex Links	Yes

<sup>22</sup> DTP=Dynamic Trunking Protocol

<sup>23</sup> A port configured with the **switchport mode dynamic** interface configuration command.

- <sup>24</sup> A VLAN Query Protocol (VQP) port configured with the **switchport access vlan dynamic** interface configuration command.
- <sup>25</sup> You must set the maximum allowed secure addresses on the port to two plus the maximum number of secure addresses allowed on the access VLAN.

## Overview of Port-Based Traffic Control

Port-based traffic control is a set of Layer 2 features on the Cisco Catalyst switches used to filter or block packets at the port level in response to specific traffic conditions. The following port-based traffic control features are supported:

- Storm Control
- Protected Ports
- Port Blocking
- Port Security
- Protocol Storm Protection

## How to Configure Port Security

### Enabling and Configuring Port Security

#### Before you begin

This task restricts input to an interface by limiting and identifying MAC addresses of the stations allowed to access the port:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b>	Specifies the interface to be configured, and enter interface configuration mode.

	Command or Action	Purpose
	Device (config) # <b>interface</b> <b>gigabitethernet1/0/1</b>	
<b>Step 4</b>	<b>switchport mode {access   trunk}</b> <b>Example:</b> Device (config-if) # <b>switchport mode</b> <b>access</b>	Sets the interface switchport mode as access or trunk; an interface in the default mode (dynamic auto) cannot be configured as a secure port.
<b>Step 5</b>	<b>switchport voice vlan <i>vlan-id</i></b> <b>Example:</b> Device (config-if) # <b>switchport voice vlan</b> <b>22</b>	Enables voice VLAN on a port.  <i>vlan-id</i> —Specifies the VLAN to be used for voice traffic.
<b>Step 6</b>	<b>switchport port-security</b> <b>Example:</b> Device (config-if) # <b>switchport</b> <b>port-security</b>	Enable port security on the interface.  <b>Note</b> Under certain conditions, when port security is enabled on the member ports in a switch stack, the DHCP and ARP packets would be dropped. To resolve this, configure a shut and no shut on the interface.
<b>Step 7</b>	<b>switchport port-security [maximum <i>value</i> [vlan {<i>vlan-list</i>   {access   voice}}]]</b> <b>Example:</b> Device (config-if) # <b>switchport</b> <b>port-security maximum 20</b>	(Optional) Sets the maximum number of secure MAC addresses for the interface. The maximum number of secure MAC addresses that you can configure on a switch or switch stack is set by the maximum number of available MAC addresses allowed in the system. This number is set by the active Switch Database Management (SDM) template. This number is the total of available MAC addresses, including those used for other Layer 2 functions and any other secure MAC addresses configured on interfaces.  (Optional) <b>vlan</b> —sets a per-VLAN maximum value  Enter one of these options after you enter the <b>vlan</b> keyword:  <ul style="list-style-type: none"> <li>• <i>vlan-list</i>—On a trunk port, you can set a per-VLAN maximum value on a range of VLANs separated by a hyphen or a series of VLANs separated by commas. For nonspecified VLANs, the per-VLAN maximum value is used.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>access</b>—On an access port, specifies the VLAN as an access VLAN.</li> <li>• <b>voice</b>—On an access port, specifies the VLAN as a voice VLAN.</li> </ul> <p><b>Note</b> The <b>voice</b> keyword is available only if a voice VLAN is configured on a port and if that port is not the access VLAN. If an interface is configured for voice VLAN, configure a maximum of two secure MAC addresses.</p>
<b>Step 8</b>	<p><b>switchport port-security violation {protect   restrict   shutdown   shutdown vlan}</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# switchport port-security violation restrict</pre>	<p>(Optional) Sets the violation mode, the action to be taken when a security violation is detected, as one of these:</p> <ul style="list-style-type: none"> <li>• <b>protect</b>—When the number of port secure MAC addresses reaches the maximum limit allowed on the port, packets with unknown source addresses are dropped until you remove a sufficient number of secure MAC addresses to drop below the maximum value or increase the number of maximum allowable addresses. You are not notified that a security violation has occurred.</li> <li>• <b>restrict</b>—When the number of secure MAC addresses reaches the limit allowed on the port, packets with unknown source addresses are dropped until you remove a sufficient number of secure MAC addresses or increase the number of maximum allowable addresses. An SNMP trap is sent, a syslog message is logged, and the violation counter increments.</li> <li>• <b>shutdown</b>—The interface is error-disabled when a violation occurs, and the port LED turns off. An SNMP</li> </ul> <p><b>Note</b> We do not recommend configuring the protect mode on a trunk port. The protect mode disables learning when any VLAN reaches its maximum limit, even if the port has not reached its maximum limit.</p>



	Command or Action	Purpose
		<p>trap is sent, a syslog message is logged, and the violation counter increments.</p> <ul style="list-style-type: none"> <li>• <b>shutdown vlan</b>—Use to set the security violation mode per VLAN. In this mode, the VLAN is error disabled instead of the entire port when a violation occurs.</li> </ul> <p><b>Note</b> When a secure port is in the error-disabled state, you can bring it out of this state by entering the <b>errdisable recovery cause psecure-violation</b> global configuration command. You can manually re-enable it by entering the <b>shutdown</b> and <b>no shutdown</b> interface configuration commands or by using the <b>clear errdisable interface vlan</b> privileged EXEC command.</p>
<p><b>Step 9</b></p>	<p><b>switchport port-security [mac-address mac-address [vlan {vlan-id} {access   voice}]]</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# switchport port-security mac-address 00:A0:C7:12:C9:25 vlan 3 voice</pre>	<p>(Optional) Enters a secure MAC address for the interface. You can use this command to enter the maximum number of secure MAC addresses. If you configure fewer secure MAC addresses than the maximum, the remaining MAC addresses are dynamically learned.</p> <p><b>Note</b> If you enable sticky learning after you enter this command, the secure addresses that were dynamically learned are converted to sticky secure MAC addresses and are added to the running configuration.</p> <p>(Optional) <b>vlan</b>—sets a per-VLAN maximum value.</p> <p>Enter one of these options after you enter the <b>vlan</b> keyword:</p> <ul style="list-style-type: none"> <li>• <b>vlan-id</b>—On a trunk port, you can specify the VLAN ID and the MAC address. If you do not specify a VLAN ID, the native VLAN is used.</li> <li>• <b>access</b>—On an access port, specifies the VLAN as an access VLAN.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>voice</b>—On an access port, specifies the VLAN as a voice VLAN.</li> </ul> <p><b>Note</b> The <b>voice</b> keyword is available only if a voice VLAN is configured on a port and if that port is not the access VLAN. If an interface is configured for voice VLAN, configure a maximum of two secure MAC addresses.</p>
<b>Step 10</b>	<b>switchport port-security mac-address sticky</b> <b>Example:</b> <pre>Device(config-if)# switchport port-security mac-address sticky</pre>	(Optional) Enables sticky learning on the interface.
<b>Step 11</b>	<b>switchport port-security mac-address sticky</b> <code>[mac-address   vlan {vlan-id   {access   voice}}]</code> <b>Example:</b> <pre>Device(config-if)# switchport port-security mac-address sticky 00:A0:C7:12:C9:25 vlan voice</pre>	(Optional) Enters a sticky secure MAC address, repeating the command as many times as necessary. If you configure fewer secure MAC addresses than the maximum, the remaining MAC addresses are dynamically learned, are converted to sticky secure MAC addresses, and are added to the running configuration. <p><b>Note</b> If you do not enable sticky learning before this command is entered, an error message appears, and you cannot enter a sticky secure MAC address.</p> <p>(Optional) <b>vlan</b>—sets a per-VLAN maximum value.</p> <p>Enter one of these options after you enter the <b>vlan</b> keyword:</p> <ul style="list-style-type: none"> <li>• <b>vlan-id</b>—On a trunk port, you can specify the VLAN ID and the MAC address. If you do not specify a VLAN ID, the native VLAN is used.</li> <li>• <b>access</b>—On an access port, specifies the VLAN as an access VLAN.</li> <li>• <b>voice</b>—On an access port, specifies the VLAN as a voice VLAN.</li> </ul>

	Command or Action	Purpose
		<b>Note</b> The <b>voice</b> keyword is available only if a voice VLAN is configured on a port and if that port is not the access VLAN.
<b>Step 12</b>	<b>end</b> <b>Example:</b>  Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 13</b>	<b>show port-security</b> <b>Example:</b>  Device# <b>show port-security</b>	Verifies your entries.
<b>Step 14</b>	<b>show running-config</b> <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries.
<b>Step 15</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Port Security](#), on page 2097

[Port Security](#), on page 2123

[Configuration Examples for Port Security](#), on page 2146

## Enabling and Configuring Port Security Aging

Use this feature to remove and add devices on a secure port without manually deleting the existing secure MAC addresses and to still limit the number of secure addresses on a port. You can enable or disable the aging of secure addresses on a per-port basis.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
	Device> <b>enable</b>	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device (config) # <b>interface gigabitethernet 1/0/1</b>	Specifies the interface to be configured, and enter interface configuration mode.
<b>Step 4</b>	<b>switchport port-security aging {static   time <i>time</i>   type {absolute   inactivity}}</b> <b>Example:</b> Device (config-if) # <b>switchport port-security aging time 120</b>	Enables or disable static aging for the secure port, or set the aging time or type.  <b>Note</b> The switch does not support port security aging of sticky secure addresses.  Enter <b>static</b> to enable aging for statically configured secure addresses on this port.  For <i>time</i> , specifies the aging time for this port. The valid range is from 0 to 1440 minutes.  For <b>type</b> , select one of these keywords: <ul style="list-style-type: none"> <li>• <b>absolute</b>—Sets the aging type as absolute aging. All the secure addresses on this port age out exactly after the time (minutes) specified lapses and are removed from the secure address list.</li> <li>• <b>inactivity</b>—Sets the aging type as inactivity aging. The secure addresses on this port age out only if there is no data traffic from the secure source addresses for the specified time period.</li> </ul>
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show port-security [interface <i>interface-id</i>] [address]</b>	Verifies your entries.

	Command or Action	Purpose
	<b>Example:</b>  Device# <code>show port-security interface gigabitethernet 1/0/1</code>	
<b>Step 7</b>	<b>show running-config</b>  <b>Example:</b>  Device# <code>show running-config</code>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b>  <b>Example:</b>  Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

#### Related Topics

[Port Security Aging](#), on page 2125

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

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## Information About Storm Control

### Storm Control

Storm control prevents traffic on a LAN from being disrupted by a broadcast, multicast, or unicast storm on one of the physical interfaces. A LAN storm occurs when packets flood the LAN, creating excessive traffic and degrading network performance. Errors in the protocol-stack implementation, mistakes in network configurations, or users issuing a denial-of-service attack can cause a storm.

Storm control (or traffic suppression) monitors packets passing from an interface to the switching bus and determines if the packet is unicast, multicast, or broadcast. The switch counts the number of packets of a specified type received within the 1-second time interval and compares the measurement with a predefined suppression-level threshold.

### How Traffic Activity is Measured

Storm control uses one of these methods to measure traffic activity:

- Bandwidth as a percentage of the total available bandwidth of the port that can be used by the broadcast, multicast, or unicast traffic
- Traffic rate in packets per second at which broadcast, multicast, or unicast packets are received
- Traffic rate in bits per second at which broadcast, multicast, or unicast packets are received
- Traffic rate in packets per second and for small frames. This feature is enabled globally. The threshold for small frames is configured for each interface.

With each method, the port blocks traffic when the rising threshold is reached. The port remains blocked until the traffic rate drops below the falling threshold (if one is specified) and then resumes normal forwarding. If the falling suppression level is not specified, the switch blocks all traffic until the traffic rate drops below the rising suppression level. In general, the higher the level, the less effective the protection against broadcast storms.

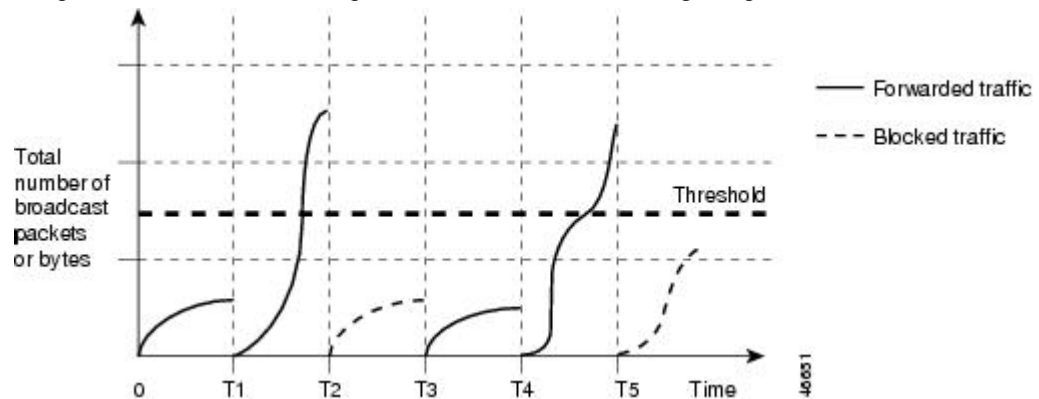

**Note**

When the storm control threshold for multicast traffic is reached, all multicast traffic except control traffic, such as bridge protocol data unit (BPDU) and Cisco Discovery Protocol (CDP) frames, are blocked. However, the switch does not differentiate between routing updates, such as OSPF, and regular multicast data traffic, so both types of traffic are blocked.

## Traffic Patterns

**Figure 139: Broadcast Storm Control Example**

This example shows broadcast traffic patterns on an interface over a given period of time.



Broadcast traffic being forwarded exceeded the configured threshold between time intervals T1 and T2 and between T4 and T5. When the amount of specified traffic exceeds the threshold, all traffic of that kind is dropped for the next time period. Therefore, broadcast traffic is blocked during the intervals following T2 and T5. At the next time interval (for example, T3), if broadcast traffic does not exceed the threshold, it is again forwarded.

The combination of the storm-control suppression level and the 1-second time interval controls the way the storm control algorithm works. A higher threshold allows more packets to pass through. A threshold value of 100 percent means that no limit is placed on the traffic. A value of 0.0 means that all broadcast, multicast, or unicast traffic on that port is blocked.



**Note** Because packets do not arrive at uniform intervals, the 1-second time interval during which traffic activity is measured can affect the behavior of storm control.

You use the **storm-control** interface configuration commands to set the threshold value for each traffic type.

## How to Configure Storm Control

### Configuring Storm Control and Threshold Levels

You configure storm control on a port and enter the threshold level that you want to be used for a particular type of traffic.

However, because of hardware limitations and the way in which packets of different sizes are counted, threshold percentages are approximations. Depending on the sizes of the packets making up the incoming traffic, the actual enforced threshold might differ from the configured level by several percentage points.



**Note** Storm control is supported on physical interfaces. You can also configure storm control on an EtherChannel. When storm control is configured on an EtherChannel, the storm control settings propagate to the EtherChannel physical interfaces.

Follow these steps to storm control and threshold levels:

#### Before you begin

Storm control is supported on physical interfaces. You can also configure storm control on an EtherChannel. When storm control is configured on an EtherChannel, the storm control settings propagate to the EtherChannel physical interfaces.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b>	Specifies the interface to be configured, and enter interface configuration mode.

	Command or Action	Purpose
	<pre>Device(config)# interface gigabitethernet1/0/1</pre>	
<b>Step 4</b>	<p><b>storm-control</b> {<b>broadcast</b>   <b>multicast</b>   <b>unicast</b>} <b>level</b> {<i>level</i> [<i>level-low</i>]   <b>bps</b> <i>bps</i> [<i>bps-low</i>]   <b>pps</b> <i>pps</i> [<i>pps-low</i>]}</p> <p><b>Example:</b></p> <pre>Device(config-if)# storm-control unicast level 87 65</pre>	<p>Configures broadcast, multicast, or unicast storm control. By default, storm control is disabled.</p> <p>The keywords have these meanings:</p> <ul style="list-style-type: none"> <li>For <i>level</i>, specifies the rising threshold level for broadcast, multicast, or unicast traffic as a percentage (up to two decimal places) of the bandwidth. The port blocks traffic when the rising threshold is reached. The range is 0.00 to 100.00.</li> <li>(Optional) For <i>level-low</i>, specifies the falling threshold level as a percentage (up to two decimal places) of the bandwidth. This value must be less than or equal to the rising suppression value. The port forwards traffic when traffic drops below this level. If you do not configure a falling suppression level, it is set to the rising suppression level. The range is 0.00 to 100.00.</li> </ul> <p>If you set the threshold to the maximum value (100 percent), no limit is placed on the traffic. If you set the threshold to 0.0, all broadcast, multicast, and unicast traffic on that port is blocked.</p> <ul style="list-style-type: none"> <li>For <b>bps</b> <i>bps</i>, specifies the rising threshold level for broadcast, multicast, or unicast traffic in bits per second (up to one decimal place). The port blocks traffic when the rising threshold is reached. The range is 0.0 to 10000000000.0.</li> <li>(Optional) For <i>bps-low</i>, specifies the falling threshold level in bits per second (up to one decimal place). It can be less than or equal to the rising threshold level. The port forwards traffic when traffic drops below this level. The range is 0.0 to 10000000000.0.</li> <li>For <b>pps</b> <i>pps</i>, specifies the rising threshold level for broadcast, multicast, or unicast traffic in packets per second (up to one decimal place). The port blocks traffic</li> </ul>



	Command or Action	Purpose
		<p>when the rising threshold is reached. The range is 0.0 to 10000000000.0.</p> <ul style="list-style-type: none"> <li>• (Optional) For <i>pps-low</i>, specifies the falling threshold level in packets per second (up to one decimal place). It can be less than or equal to the rising threshold level. The port forwards traffic when traffic drops below this level. The range is <b>0.0 to 10000000000.0</b>.</li> </ul> <p>For BPS and PPS settings, you can use metric suffixes such as k, m, and g for large number thresholds.</p>
<b>Step 5</b>	<p><b>storm-control action {shutdown   trap}</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# storm-control action trap</pre>	<p>Specifies the action to be taken when a storm is detected. The default is to filter out the traffic and not to send traps.</p> <ul style="list-style-type: none"> <li>• Select the <b>shutdown</b> keyword to error-disable the port during a storm.</li> <li>• Select the <b>trap</b> keyword to generate an SNMP trap when a storm is detected.</li> </ul>
<b>Step 6</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# end</pre>	Returns to privileged EXEC mode.
<b>Step 7</b>	<p><b>show storm-control [interface-id] [broadcast   multicast   unicast]</b></p> <p><b>Example:</b></p> <pre>Device# show storm-control gigabitethernet1/0/1 unicast</pre>	Verifies the storm control suppression levels set on the interface for the specified traffic type. If you do not enter a traffic type, details for all traffic types (broadcast, multicast and unicast) are displayed.
<b>Step 8</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

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## Information About Protected Ports

### Protected Ports

Some applications require that no traffic be forwarded at Layer 2 between ports on the same switch so that one neighbor does not see the traffic generated by another neighbor. In such an environment, the use of protected ports ensures that there is no exchange of unicast, broadcast, or multicast traffic between these ports on the switch.

Protected ports have these features:

- A protected port does not forward any traffic (unicast, multicast, or broadcast) to any other port that is also a protected port. Data traffic cannot be forwarded between protected ports at Layer 2; only control traffic, such as PIM packets, is forwarded because these packets are processed by the CPU and forwarded in software. All data traffic passing between protected ports must be forwarded through a Layer 3 device.
- Forwarding behavior between a protected port and a nonprotected port proceeds as usual.

Because a switch stack represents a single logical switch, Layer 2 traffic is not forwarded between any protected ports in the switch stack, whether they are on the same or different switches in the stack.

### Default Protected Port Configuration

The default is to have no protected ports defined.

### Protected Ports Guidelines

You can configure protected ports on a physical interface (for example, Gigabit Ethernet port 1) or an EtherChannel group (for example, port-channel 5). When you enable protected ports for a port channel, it is enabled for all ports in the port-channel group.

## How to Configure Protected Ports

### Configuring a Protected Port

#### Before you begin

Protected ports are not pre-defined. This is the task to configure one.

#### Procedure

	Command or Action	Purpose
Step 1	enable  Example:	Enables privileged EXEC mode.  • Enter your password if prompted.

	Command or Action	Purpose
	Device> <b>enable</b>	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/1</b>	Specifies the interface to be configured, and enter interface configuration mode.
<b>Step 4</b>	<b>switchport protected</b> <b>Example:</b> Device(config-if)# <b>switchport protected</b>	Configures the interface to be a protected port.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show interfaces <i>interface-id</i> switchport</b> <b>Example:</b> Device# <b>show interfaces gigabitethernet 1/0/1 switchport</b>	Verifies your entries.
<b>Step 7</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Monitoring Protected Ports

Table 164: Commands for Displaying Protected Port Settings

Command	Purpose
<code>show interfaces [interface-id] switchport</code>	Displays the administrative and operational status of all switching (nonrouting) ports or the specified port, including port blocking and port protection settings.

## Where to Go Next

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## Additional References

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information

Release	Feature Information
Cisco IOS XE 3.2SE	This feature was introduced.

## Finding Feature Information

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## Information About Port Blocking

### Port Blocking

By default, the switch floods packets with unknown destination MAC addresses out of all ports. If unknown unicast and multicast traffic is forwarded to a protected port, there could be security issues. To prevent unknown unicast or multicast traffic from being forwarded from one port to another, you can block a port (protected or nonprotected) from flooding unknown unicast or multicast packets to other ports.



**Note** With multicast traffic, the port blocking feature blocks only pure Layer 2 packets. Multicast packets that contain IPv4 or IPv6 information in the header are not blocked.

## How to Configure Port Blocking

### Blocking Flooded Traffic on an Interface

#### Before you begin

The interface can be a physical interface or an EtherChannel group. When you block multicast or unicast traffic for a port channel, it is blocked on all ports in the port-channel group.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>interface</b> <i>interface-id</i> <b>Example:</b> Device(config)# <b>interface</b> gigabitethernet 1/0/1	Specifies the interface to be configured, and enter interface configuration mode.
<b>Step 4</b>	<b>switchport block multicast</b> <b>Example:</b> Device(config-if)# <b>switchport block</b> <b>multicast</b>	Blocks unknown multicast forwarding out of the port.
<b>Step 5</b>	<b>switchport block unicast</b> <b>Example:</b> Device(config-if)# <b>switchport block</b> <b>unicast</b>	Blocks unknown unicast forwarding out of the port.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show interfaces</b> <i>interface-id</i> <b>switchport</b> <b>Example:</b> Device# <b>show interfaces</b> gigabitethernet 1/0/1 <b>switchport</b>	Verifies your entries.
<b>Step 8</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies your entries.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

## Monitoring Port Blocking

Table 165: Commands for Displaying Port Blocking Settings

Command	Purpose
<code>show interfaces [interface-id] switchport</code>	Displays the administrative and operational status of all switching (nonrouting) ports or the specified port, including port blocking and port protection settings.

## Where to Go Next

.

## Additional References

### Related Documents

Related Topic	Document Title

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### Standards and RFCs

Standard/RFC	Title

### MIBs

MB	MIBs Link
	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information

Release	Feature Information
Cisco IOS XE 3.2SE	This feature was introduced.

## Monitoring Port Security

This table displays port security information.

*Table 166: Commands for Displaying Port Security Status and Configuration*

Command	Purpose
<b>show port-security</b> [ <b>interface</b> <i>interface-id</i> ]	Displays port security settings for the switch or for the specified interface, including the maximum allowed number of secure MAC addresses for each interface, the number of secure MAC addresses on the interface, the number of security violations that have occurred, and the violation mode.
<b>show port-security</b> [ <b>interface</b> <i>interface-id</i> ] <b>address</b>	Displays all secure MAC addresses configured on all switch interfaces or on a specified interface with aging information for each address.
<b>show port-security</b> <b>interface</b> <i>interface-id</i> <b>vlan</b>	Displays the number of secure MAC addresses configured per VLAN on the specified interface.

## Configuration Examples for Port Security

This example shows how to enable port security on a port and to set the maximum number of secure addresses to 50. The violation mode is the default, no static secure MAC addresses are configured, and sticky learning is enabled.



```
Device(config)# interface gigabitethernet 1/0/1
Device(config-if)# switchport mode access
Device(config-if)# switchport port-security
Device(config-if)# switchport port-security maximum 50
Device(config-if)# switchport port-security mac-address sticky
```

This example shows how to configure a static secure MAC address on VLAN 3 on a port:

```
Device(config)# interface gigabitethernet 1/0/2
Device(config-if)# switchport mode trunk
Device(config-if)# switchport port-security
Device(config-if)# switchport port-security mac-address 0000.0200.0004 vlan 3
```

This example shows how to enable sticky port security on a port, to manually configure MAC addresses for data VLAN and voice VLAN, and to set the total maximum number of secure addresses to 20 (10 for data VLAN and 10 for voice VLAN).

```
Device(config)# interface tengigabitethernet 1/0/1
Device(config-if)# switchport access vlan 21
Device(config-if)# switchport mode access
Device(config-if)# switchport voice vlan 22
Device(config-if)# switchport port-security
Device(config-if)# switchport port-security maximum 20
Device(config-if)# switchport port-security violation restrict
Device(config-if)# switchport port-security mac-address sticky
Device(config-if)# switchport port-security mac-address sticky 0000.0000.0002
Device(config-if)# switchport port-security mac-address 0000.0000.0003
Device(config-if)# switchport port-security mac-address sticky 0000.0000.0001 vlan voice
Device(config-if)# switchport port-security mac-address 0000.0000.0004 vlan voice
Device(config-if)# switchport port-security maximum 10 vlan access
Device(config-if)# switchport port-security maximum 10 vlan voice
```

### Related Topics

[Port Security](#), on page 2123

[Enabling and Configuring Port Security](#), on page 2128





## CHAPTER 114

# Configuring IPv6 First Hop Security

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- Prerequisites for First Hop Security in IPv6, on page 2149
- Restrictions for First Hop Security in IPv6, on page 2150
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- How to Configure an IPv6 Neighbor Discovery Inspection Policy, on page 2158
- How to Configure an IPv6 Router Advertisement Guard Policy, on page 2162
- **How to Configure an IPv6 DHCP Guard Policy** , on page 2167
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- Additional References, on page 2178

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for First Hop Security in IPv6

- You have configured the necessary IPv6 enabled SDM template.
- You should be familiar with the IPv6 neighbor discovery feature.

## Restrictions for First Hop Security in IPv6

- The following restrictions apply when applying FHS policies to EtherChannel interfaces (Port Channels):
  - A physical port with an FHS policy attached cannot join an EtherChannel group.
  - An FHS policy cannot be attached to a physical port when it is a member of an EtherChannel group.
- By default, a snooping policy has a security-level of guard. When such a snooping policy is configured on an access switch, external IPv6 Router Advertisement (RA) or Dynamic Host Configuration Protocol server packets are blocked, even though the uplink port facing the router or DHCP server/relay is configured as a trusted port. To allow IPv6 RA or DHCPv6 server messages, do the following:
  - Apply an IPv6 RA-guard policy (for RA) or IPv6 DHCP-guard policy (for DHCP server messages) on the uplink port.
  - Configure a snooping policy with a lower security-level, for example glean or inspect. However, configuring a lower security level is not recommended with such a snooping policy, because benefits of First Hop security features are not effective.

## Information about First Hop Security in IPv6

First Hop Security in IPv6 (FHS IPv6) is a set of IPv6 security features, the policies of which can be attached to a physical interface, an EtherChannel interface, or a VLAN. An IPv6 software policy database service stores and accesses these policies. When a policy is configured or modified, the attributes of the policy are stored or updated in the software policy database, then applied as was specified. The following IPv6 policies are currently supported:

- IPv6 Snooping Policy—IPv6 Snooping Policy acts as a container policy that enables most of the features available with FHS in IPv6.
- IPv6 FHS Binding Table Content—A database table of IPv6 neighbors connected to the switch is created from information sources such as Neighbor Discovery (ND) protocol snooping. This database, or binding, table is used by various IPv6 guard features (such as IPv6 ND Inspection) to validate the link-layer address (LLA), the IPv4 or IPv6 address, and prefix binding of the neighbors to prevent spoofing and redirect attacks.
- IPv6 Neighbor Discovery Inspection—IPv6 ND inspection learns and secures bindings for stateless autoconfiguration addresses in Layer 2 neighbor tables. IPv6 ND inspection analyzes neighbor discovery messages in order to build a trusted binding table database and IPv6 neighbor discovery messages that do not conform are dropped. An ND message is considered trustworthy if its IPv6-to-Media Access Control (MAC) mapping is verifiable.

This feature mitigates some of the inherent vulnerabilities of the ND mechanism, such as attacks on DAD, address resolution, router discovery, and the neighbor cache.



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**Note** Effective Cisco IOS XE Release 16.3.1, ND Inspection functionality, IPv6 Snooping Policy, and IPv6 FHS Binding Table Content are supported through Switch Integrated Security Feature (SISF)-based Device Tracking. For more information, see *Configuring SISF based device tracking* section of the Software Configuration Guide.

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- **IPv6 Router Advertisement Guard**—The IPv6 Router Advertisement (RA) guard feature enables the network administrator to block or reject unwanted or rogue RA guard messages that arrive at the network switch platform. RAs are used by routers to announce themselves on the link. The RA Guard feature analyzes the RAs and filters out bogus RAs sent by unauthorized routers. In host mode, all router advertisement and router redirect messages are disallowed on the port. The RA guard feature compares configuration information on the Layer 2 device with the information found in the received RA frame. Once the Layer 2 device has validated the content of the RA frame and router redirect frame against the configuration, it forwards the RA to its unicast or multicast destination. If the RA frame content is not validated, the RA is dropped.
- **IPv6 DHCP Guard**—The IPv6 DHCP Guard feature blocks reply and advertisement messages that come from unauthorized DHCPv6 servers and relay agents. IPv6 DHCP guard can prevent forged messages from being entered in the binding table and block DHCPv6 server messages when they are received on ports that are not explicitly configured as facing a DHCPv6 server or DHCP relay. To use this feature, configure a policy and attach it to an interface or a VLAN. To debug DHCP guard packets, use the **debug ipv6 snooping dhcp-guard** privileged EXEC command.
- **IPv6 Source Guard**—Like IPv4 Source Guard, IPv6 Source Guard validates the source address or prefix to prevent source address spoofing.

A source guard programs the hardware to allow or deny traffic based on source or destination addresses. It deals exclusively with data packet traffic.

The IPv6 source guard feature provides the ability to store entries in the hardware TCAM table to prevent a host from sending packets with an invalid IPv6 source address.

To debug source-guard packets, use the `debug ipv6 snooping source-guard` privileged EXEC command.



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**Note** The IPv6 source guard and prefix guard features are supported only in the ingress direction; it is not supported in the egress direction.

---

The following restrictions apply:

- An FHS policy cannot be attached to an physical port when it is a member of an EtherChannel group.
- When IPv6 source guard is enabled on a switch port, NDP or DHCP snooping must be enabled on the interface to which the switch port belongs. Otherwise, all data traffic from this port will be blocked.
- An IPv6 source guard policy cannot be attached to a VLAN. It is supported only at the interface level.
- When you configure IPv4 and IPv6 source guard together on an interface, it is recommended to use **ip verify source mac-check** instead of **ip verify source**. IPv4 connectivity on a given port might

break due to two different filtering rules set — one for IPv4 (IP-filter) and the other for IPv6 (IP-MAC filter).

- You cannot use IPv6 Source Guard and Prefix Guard together. When you attach the policy to an interface, it should be "validate address" or "validate prefix" but not both.
- PVLAN and Source/Prefix Guard cannot be applied together.
- IPv6 Source Guard and Prefix Guard is supported on EtherChannels

For more information on IPv6 Source Guard, see the [IPv6 Source Guard](#) chapter of the Cisco IOS IPv6 Configuration Guide Library on Cisco.com.

- IPv6 Prefix Guard—The IPv6 prefix guard feature works within the IPv6 source guard feature, to enable the device to deny traffic originated from non-topologically correct addresses. IPv6 prefix guard is often used when IPv6 prefixes are delegated to devices (for example, home gateways) using DHCP prefix delegation. The feature discovers ranges of addresses assigned to the link and blocks any traffic sourced with an address outside this range.

For more information on IPv6 Prefix Guard, see the [IPv6 Prefix Guard](#) chapter of the Cisco IOS IPv6 Configuration Guide Library on Cisco.com.

- IPv6 Destination Guard—The IPv6 destination guard feature works with IPv6 neighbor discovery to ensure that the device performs address resolution only for those addresses that are known to be active on the link. It relies on the address glean functionality to populate all destinations active on the link into the binding table and then blocks resolutions before they happen when the destination is not found in the binding table.




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**Note** IPv6 Destination Guard is recommended to apply on Layer 2 VLAN with an SVI configured

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For more information about IPv6 Destination Guard, see the [IPv6 Destination Guard](#) chapter of the Cisco IOS IPv6 Configuration Guide Library on Cisco.com.

## How to Configure an IPv6 Snooping Policy

The IPv6 Snooping Policy feature is deprecated starting from Cisco IOS XE Denali 16.3.1. Although the commands are visible on the CLI and you can configure them, we recommend that you use the Switch Integrated Security Feature (SISF)-based Device Tracking feature instead.

Beginning in privileged EXEC mode, follow these steps to configure IPv6 Snooping Policy :

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>ipv6 snooping policy</b> <i>policy-name</i> <b>Example:</b> Device(config)# <b>ipv6 snooping policy</b> <b>example_policy</b>	Creates a snooping policy and enters IPv6 Snooping Policy Configuration mode.
<b>Step 3</b>	<pre>{[<b>default</b>]   [<b>device-role</b> {<b>node</b>   <b>switch</b>}]   [<b>limit address-count</b> <i>value</i>]   [<b>no</b>]   [<b>protocol</b> {<b>dhcp</b>   <b>ndp</b>}]   [<b>security-level</b> {<b>glean</b>   <b>guard</b>   <b>inspect</b>}]   [<b>tracking</b> {<b>disable</b> [<b>stale-lifetime</b> [<i>seconds</i>   <b>infinite</b>]   <b>enable</b> [<b>reachable-lifetime</b> [<i>seconds</i>   <b>infinite</b>] } ]   [<b>trusted-port</b>] }</pre> <b>Example:</b> Device ( <b>config-ipv6-snooping</b> ) # <b>security-level inspect</b> <b>Example:</b> Device ( <b>config-ipv6-snooping</b> ) # <b>trusted-port</b>	Enables data address gleaning, validates messages against various criteria, specifies the security level for messages. <ul style="list-style-type: none"> <li>• (Optional) <b>default</b>—Sets all to default options.</li> <li>• (Optional) <b>device-role</b>{<b>node</b>   <b>switch</b>}—Specifies the role of the device attached to the port. Default is <b>node</b>.</li> <li>• (Optional) <b>limit address-count</b> <i>value</i>—Limits the number of addresses allowed per target.</li> <li>• (Optional) <b>no</b>—Negates a command or sets it to defaults.</li> <li>• (Optional) <b>protocol</b>{<b>dhcp</b>   <b>ndp</b>}—Specifies which protocol should be redirected to the snooping feature for analysis. The default, is <b>dhcp</b> and <b>ndp</b>. To change the default, use the <b>no protocol</b> command.</li> <li>• (Optional) <b>security-level</b>{<b>glean</b> <b>guard</b> <b>inspect</b>}—Specifies the level of security enforced by the feature. Default is <b>guard</b>.               <ul style="list-style-type: none"> <li><b>glean</b>—Gleans addresses from messages and populates the binding table without any verification.</li> <li><b>guard</b>—Gleans addresses and inspects messages. In addition, it rejects RA and DHCP server messages. This is the default option.</li> <li><b>inspect</b>—Gleans addresses, validates messages for consistency and conformance, and enforces address ownership.</li> </ul> </li> <li>• (Optional) <b>tracking</b> {<b>disable</b>   <b>enable</b>}—Overrides the default tracking behavior and specifies a tracking option.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>(Optional) <b>trusted-port</b>—Sets up a trusted port. It disables the guard on applicable targets. Bindings learned through a trusted port have preference over bindings learned through any other port. A trusted port is given preference in case of a collision while making an entry in the table.</li> </ul>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config-ipv6-snooping)# <b>exit</b>	Exits configuration modes to Privileged EXEC mode.
<b>Step 5</b>	<b>show ipv6 snooping policy <i>policy-name</i></b> <b>Example:</b> Device# <b>show ipv6 snooping policy example_policy</b>	Displays the snooping policy configuration.

**What to do next**

Attach an IPv6 Snooping policy to interfaces or VLANs.

## How to Attach an IPv6 Snooping Policy to an Interface

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 Snooping policy on an interface or VLAN:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 2</b>	<b>interface Interface_type <i>stack/module/port</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/1/4</b>	Specifies an interface type and identifier; enters the interface configuration mode.
<b>Step 3</b>	<b>switchport</b> <b>Example:</b>	Enters the Switchport mode.



	Command or Action	Purpose
	Device(config-if)# <b>switchport</b>	<b>Note</b> To configure Layer 2 parameters, if the interface is in Layer 3 mode, you must enter the switchport interface configuration command without any parameters to put the interface into Layer 2 mode. This shuts down the interface and then re-enables it, which might generate messages on the device to which the interface is connected. When you put an interface that is in Layer 3 mode into Layer 2 mode, the previous configuration information related to the affected interface might be lost, and the interface is returned to its default configuration. The command prompt displays as (config-if)# in Switchport configuration mode.
<b>Step 4</b>	<p><b>ipv6 snooping</b> [<b>attach-policy</b> <i>policy_name</i> [ <b>vlan</b> {<i>vlan_id</i>   <b>add</b> <i>vlan_ids</i>   <b>except</b><i>vlan_ids</i>   <b>none</b>   <b>remove</b> <i>vlan_ids</i>}]   <b>vlan</b> {<i>vlan_id</i>   <b>add</b> <i>vlan_ids</i>   <b>except</b><i>vlan_ids</i>   <b>none</b>   <b>remove</b> <i>vlan_ids</i>   <b>all</b>} ]</p> <p><b>Example:</b></p> <pre>Device(config-if)# ipv6 snooping</pre> <p>or</p> <pre>Device(config-if)# ipv6 snooping attach-policy example_policy</pre> <p>or</p> <pre>Device(config-if)# ipv6 snooping vlan 111,112</pre> <p>or</p> <pre>Device(config-if)# ipv6 snooping attach-policy example_policy vlan 111,112</pre>	Attaches a custom ipv6 snooping policy to the interface or the specified VLANs on the interface. To attach the default policy to the interface, use the <b>ipv6 snooping</b> command without the <b>attach-policy</b> keyword. To attach the default policy to VLANs on the interface, use the <b>ipv6 snooping vlan</b> command. The default policy is, security-level <b>guard</b> , device-role <b>node</b> , protocol <b>ndp</b> and <b>dhcp</b> .
<b>Step 5</b>	<p><b>do show running-config</b></p> <p><b>Example:</b></p> <pre>Device#(config-if)# do show running-config</pre>	Verifies that the policy is attached to the specified interface without exiting the interface configuration mode.

# How to Attach an IPv6 Snooping Policy to a Layer 2 EtherChannel Interface

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 Snooping policy on an EtherChannel interface or VLAN:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 2</b>	<b>interface range</b> <i>Interface_name</i> <b>Example:</b> Device(config)# <b>interface range Po11</b>	Specify the port-channel interface name assigned when the EtherChannel was created. Enters the interface range configuration mode. <b>Tip</b> Enter the <b>do show interfaces summary</b> command for quick reference to interface names and types.
<b>Step 3</b>	<b>ipv6 snooping</b> [ <b>attach-policy</b> <i>policy_name</i> [ <b>vlan</b> { <i>vlan_ids</i>   <b>add</b> <i>vlan_ids</i>   <b>except</b> <i>vlan_ids</i>   <b>none</b>   <b>remove</b> <i>vlan_ids</i>   <b>all</b> } ]   <b>vlan</b> [ { <i>vlan_ids</i>   <b>add</b> <i>vlan_ids</i>   <b>except</b> <i>vlan_ids</i>   <b>none</b>   <b>remove</b> <i>vlan_ids</i>   <b>all</b> } ] ] <b>Example:</b> Device(config-if-range)# <b>ipv6 snooping attach-policy example_policy</b> or Device(config-if-range)# <b>ipv6 snooping attach-policy example_policy vlan 222,223,224</b> or Device(config-if-range)# <b>ipv6 snooping vlan 222, 223,224</b>	Attaches the IPv6 Snooping policy to the interface or the specified VLANs on that interface. The default policy is attached if the <b>attach-policy</b> option is not used.
<b>Step 4</b>	<b>do show running-config interfaceportchannel</b> <i>interface_name</i> <b>Example:</b> Device#(config-if-range)# <b>do show running-config int poll</b>	Confirms that the policy is attached to the specified interface without exiting the configuration mode.

## How to Attach an IPv6 Snooping Policy to VLANs Globally

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 Snooping Policy to VLANs across multiple interfaces:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters the global configuration mode.
<b>Step 2</b>	<b>vlan configuration <i>vlan_list</i></b>  <b>Example:</b> Device(config)# <code>vlan configuration 333</code>	Specifies the VLANs to which the IPv6 Snooping policy will be attached ; enters the VLAN interface configuration mode.
<b>Step 3</b>	<b>ipv6 snooping [attach-policy <i>policy_name</i>]</b>  <b>Example:</b> Device(config-vlan-config)# <code>ipv6 snooping attach-policy example_policy</code>	Attaches the IPv6 Snooping policy to the specified VLANs across all switch and stack interfaces. The default policy is attached if the <b>attach-policy</b> option is not used. The default policy is, security-level <b>guard</b> , device-role <b>node</b> , protocol <b>ndp</b> and <b>dhcp</b> .
<b>Step 4</b>	<b>do show running-config</b>  <b>Example:</b> Device#(config-if)# <code>do show running-config</code>	Verifies that the policy is attached to the specified VLANs without exiting the interface configuration mode.

## How to Configure the IPv6 Binding Table Content

Beginning in privileged EXEC mode, follow these steps to configure IPv6 Binding Table Content :

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters the global configuration mode.
<b>Step 2</b>	<b>[no] ipv6 neighbor binding [vlan <i>vlan-id</i> {<i>ipv6-address</i> interface interface_type</b>	Adds a static entry to the binding table database.

	Command or Action	Purpose
	<code>stack/module/port hw_address</code> <code>[reachable-lifetimevalue [seconds   default   infinite]   [tracking { [default   disable] [reachable-lifetimevalue [seconds   default   infinite]   [enable [reachable-lifetimevalue [seconds   default   infinite]   [retry-interval {seconds  default [reachable-lifetimevalue [seconds   default   infinite] } } ]</code> <b>Example:</b> <code>Device(config)# ipv6 neighbor binding</code>	<b>Note</b> Switch adds small variance to configured reachable-time value to improve system stability during timer expiry of binding entries.
<b>Step 3</b>	<code>[no] ipv6 neighbor binding max-entries number [mac-limit number   port-limit number [mac-limit number]   vlan-limit number [mac-limit number]   [port-limit number [mac-limitnumber] ] ] ]</code> <b>Example:</b> <code>Device(config)# ipv6 neighbor binding max-entries 30000</code>	Specifies the maximum number of entries that are allowed to be inserted in the binding table cache.
<b>Step 4</b>	<code>ipv6 neighbor binding logging</code> <b>Example:</b> <code>Device(config)# ipv6 neighbor binding logging</code>	Enables the logging of binding table main events.
<b>Step 5</b>	<code>exit</code> <b>Example:</b> <code>Device(config)# exit</code>	Exits global configuration mode, and places the router in privileged EXEC mode.
<b>Step 6</b>	<code>show ipv6 neighbor binding</code> <b>Example:</b> <code>Device# show ipv6 neighbor binding</code>	Displays contents of a binding table.

## How to Configure an IPv6 Neighbor Discovery Inspection Policy

Beginning in privileged EXEC mode, follow these steps to configure an IPv6 ND Inspection Policy:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>configure terminal</code> <b>Example:</b> <code>Device# configure terminal</code>	Enters the global configuration mode.

	Command or Action	Purpose
Step 2	<b>[no]ipv6 nd inspection policy</b> <i>policy-name</i> <b>Example:</b> Device(config)# <b>ipv6 nd inspection policy example_policy</b>	Specifies the ND inspection policy name and enters ND Inspection Policy configuration mode.
Step 3	<b>device-role</b> {host   switch} <b>Example:</b> Device(config-nd-inspection)# <b>device-role switch</b>	Specifies the role of the device attached to the port. The default is <b>host</b> .
Step 4	<b>limit address-count</b> <i>value</i> <b>Example:</b> Device(config-nd-inspection)# <b>limit address-count 1000</b>	Enter 1–10,000.
Step 5	<b>tracking</b> {enable [reachable-lifetime { <i>value</i>   infinite}]   disable [stale-lifetime { <i>value</i>   infinite}]} <b>Example:</b> Device(config-nd-inspection)# <b>tracking disable stale-lifetime infinite</b>	Overrides the default tracking policy on a port.
Step 6	<b>trusted-port</b> <b>Example:</b> Device(config-nd-inspection)# <b>trusted-port</b>	Configures a port to become a trusted port.
Step 7	<b>validate source-mac</b> <b>Example:</b> Device(config-nd-inspection)# <b>validate source-mac</b>	Checks the source media access control (MAC) address against the link-layer address.
Step 8	<b>no</b> {device-role   limit address-count   tracking   trusted-port   validate source-mac} <b>Example:</b> Device(config-nd-inspection)# <b>no validate source-mac</b>	Remove the current configuration of a parameter with the <b>no</b> form of the command.
Step 9	<b>default</b> {device-role   limit address-count   tracking   trusted-port   validate source-mac} <b>Example:</b> Device(config-nd-inspection)# <b>default limit address-count</b>	Restores configuration to the default values.

	Command or Action	Purpose
<b>Step 10</b>	<b>do show ipv6 nd inspection policy</b> <i>policy_name</i>  <b>Example:</b> Device(config-nd-inspection)# <b>do show</b> <b>ipv6 nd inspection policy example_policy</b>	Verifies the ND Inspection Configuration without exiting ND inspection configuration mode.

## How to Attach an IPv6 Neighbor Discovery Inspection Policy to an Interface

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 ND Inspection policy to an interface or VLANs on an interface :

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 2</b>	<b>interface</b> Interface_type <i>stack/module/port</i>  <b>Example:</b> Device(config)# <b>interface</b> <b>gigabitethernet 1/1/4</b>	Specifies an interface type and identifier; enters the interface configuration mode.
<b>Step 3</b>	<b>ipv6 nd inspection [attach-policy policy_name</b> <b>[ vlan {vlan_ids   add vlan_ids   except</b> <b>vlan_ids   none   remove vlan_ids   all} ]   vlan</b> <b>[ {vlan_ids   add vlan_ids   exceptvlan_ids  </b> <b>none   remove vlan_ids   all} ]</b>  <b>Example:</b> Device(config-if)# <b>ipv6 nd inspection</b> <b>attach-policy example_policy</b>  or  Device(config-if)# <b>ipv6 nd inspection</b> <b>attach-policy example_policy vlan</b> <b>222,223,224</b>  or  Device(config-if)# <b>ipv6 nd inspection</b> <b>vlan 222, 223,224</b>	Attaches the Neighbor Discovery Inspection policy to the interface or the specified VLANs on that interface. The default policy is attached if the <b>attach-policy</b> option is not used.

	Command or Action	Purpose
<b>Step 4</b>	<b>do show running-config</b> <b>Example:</b> Device#(config-if)# <b>do show running-config</b>	Verifies that the policy is attached to the specified interface without exiting the interface configuration mode.

## How to Attach an IPv6 Neighbor Discovery Inspection Policy to a Layer 2 EtherChannel Interface

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 Neighbor Discovery Inspection policy on an EtherChannel interface or VLAN:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 2</b>	<b>interface range</b> <i>Interface_name</i> <b>Example:</b> Device(config)# <b>interface Po11</b>	Specify the port-channel interface name assigned when the EtherChannel was created. Enters the interface range configuration mode.  <b>Tip</b> Enter the <b>do show interfaces summary</b> command for quick reference to interface names and types.
<b>Step 3</b>	<b>ipv6 nd inspection</b> [ <b>attach-policy</b> <i>policy_name</i> [ <b>vlan</b> { <i>vlan_ids</i>   <b>add</b> <i>vlan_ids</i>   <b>except</b> <i>vlan_ids</i>   <b>none</b>   <b>remove</b> <i>vlan_ids</i>   <b>all</b> } ]   <b>vlan</b> [ { <i>vlan_ids</i>   <b>add</b> <i>vlan_ids</i>   <b>except</b> <i>vlan_ids</i>   <b>none</b>   <b>remove</b> <i>vlan_ids</i>   <b>all</b> } ] ] <b>Example:</b> Device(config-if-range)# <b>ipv6 nd inspection attach-policy example_policy</b> or Device(config-if-range)# <b>ipv6 nd inspection attach-policy example_policy vlan 222,223,224</b> or Device(config-if-range)# <b>ipv6 nd inspection vlan 222, 223,224</b>	Attaches the ND Inspection policy to the interface or the specified VLANs on that interface. The default policy is attached if the <b>attach-policy</b> option is not used.

	Command or Action	Purpose
<b>Step 4</b>	<b>do show running-config</b> <b>interface</b> <i>portchannel_interface_name</i>  <b>Example:</b> Device#(config-if-range)# <b>do show</b> <b>running-config int po11</b>	Confirms that the policy is attached to the specified interface without exiting the configuration mode.

## How to Attach an IPv6 Neighbor Discovery Inspection Policy to VLANs Globally

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 ND Inspection policy to VLANs across multiple interfaces:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 2</b>	<b>vlan configuration</b> <i>vlan_list</i>  <b>Example:</b> Device(config)# <b>vlan configuration 334</b>	Specifies the VLANs to which the IPv6 Snooping policy will be attached ; enters the VLAN interface configuration mode.
<b>Step 3</b>	<b>ipv6 nd inspection [attach-policy</b> <i>policy_name</i>  <b>Example:</b> Device(config-vlan-config)# <b>ipv6 nd</b> <b>inspection attach-policy example_policy</b>	<p>Attaches the IPv6 Neighbor Discovery policy to the specified VLANs across all switch and stack interfaces. The default policy is attached if the <b>attach-policy</b> option is not used.</p> <p>The default policy is, device-role <b>host</b>, no drop-unsecure, limit address-count disabled, sec-level minimum is disabled, tracking is disabled, no trusted-port, no validate source-mac.</p>
<b>Step 4</b>	<b>do show running-config</b>  <b>Example:</b> Device#(config-if)# <b>do show</b> <b>running-config</b>	Confirms that the policy is attached to the specified VLANs without exiting the configuration mode.

## How to Configure an IPv6 Router Advertisement Guard Policy

Beginning in privileged EXEC mode, follow these steps to configure an IPv6 Router Advertisement policy :



## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 2</b>	<b>[no]ipv6 nd rguard policy <i>policy-name</i></b> <b>Example:</b> Device (config)# <b>ipv6 nd rguard policy example_policy</b>	Specifies the RA Guard policy name and enters RA Guard Policy configuration mode.
<b>Step 3</b>	<b>[no]device-role {host   monitor   router   switch}</b> <b>Example:</b> Device (config-nd-rguard) # <b>device-role switch</b>	Specifies the role of the device attached to the port. The default is <b>host</b> .  <b>Note</b> For a network with both host-facing ports and router-facing ports, along with a RA guard policy configured with <b>device-role host</b> on host-facing ports or vlan, it is mandatory to configure a RA guard policy with <b>device-role router</b> on router-facing ports to allow the RA Guard feature to work properly.
<b>Step 4</b>	<b>[no]hop-limit {maximum   minimum} value</b> <b>Example:</b> Device (config-nd-rguard) # <b>hop-limit maximum 33</b>	(1–255) Range for Maximum and Minimum Hop Limit values.  Enables filtering of Router Advertisement messages by the Hop Limit value. A rogue RA message may have a low Hop Limit value (equivalent to the IPv4 Time to Live) that when accepted by the host, prevents the host from generating traffic to destinations beyond the rogue RA message generator. An RA message with an unspecified Hop Limit value is blocked.  If not configured, this filter is disabled. Configure <b>minimum</b> to block RA messages with Hop Limit values lower than the value you specify. Configure <b>maximum</b> to block RA messages with Hop Limit values greater than the value you specify.
<b>Step 5</b>	<b>[no]managed-config-flag {off   on}</b> <b>Example:</b> Device (config-nd-rguard) # <b>managed-config-flag on</b>	Enables filtering of Router Advertisement messages by the Managed Address Configuration, or "M" flag field. A rogue RA message with an M field of 1 can cause a host to use a rogue DHCPv6 server. If not configured, this filter is disabled.

	Command or Action	Purpose
		<p><b>On</b>—Accepts and forwards RA messages with an M value of 1, blocks those with 0.</p> <p><b>Off</b>—Accepts and forwards RA messages with an M value of 0, blocks those with 1.</p>
<b>Step 6</b>	<p><code>[no]match {ipv6 access-list list   ra prefix-list list}</code></p> <p><b>Example:</b></p> <pre>Device(config-nd-raguard)# match ipv6 access-list example_list</pre>	Matches a specified prefix list or access list.
<b>Step 7</b>	<p><code>[no]other-config-flag {on   off}</code></p> <p><b>Example:</b></p> <pre>Device(config-nd-raguard)# other-config-flag on</pre>	<p>Enables filtering of Router Advertisement messages by the Other Configuration, or "O" flag field. A rouge RA message with an O field of 1 can cause a host to use a rogue DHCPv6 server. If not configured, this filter is disabled.</p> <p><b>On</b>—Accepts and forwards RA messages with an O value of 1, blocks those with 0.</p> <p><b>Off</b>—Accepts and forwards RA messages with an O value of 0, blocks those with 1.</p>
<b>Step 8</b>	<p><code>[no]router-preference maximum {high   medium   low}</code></p> <p><b>Example:</b></p> <pre>Device(config-nd-raguard)# router-preference maximum high</pre>	<p>Enables filtering of Router Advertisement messages by the Router Preference flag. If not configured, this filter is disabled.</p> <ul style="list-style-type: none"> <li>• <b>high</b>—Accepts RA messages with the Router Preference set to high, medium, or low.</li> <li>• <b>medium</b>—Blocks RA messages with the Router Preference set to high.</li> <li>• <b>low</b>—Blocks RA messages with the Router Preference set to medium and high.</li> </ul>
<b>Step 9</b>	<p><code>[no]trusted-port</code></p> <p><b>Example:</b></p> <pre>Device(config-nd-raguard)# trusted-port</pre>	When configured as a trusted port, all attached devices are trusted, and no further message verification is performed.
<b>Step 10</b>	<p><code>default {device-role   hop-limit {maximum   minimum}   managed-config-flag   match {ipv6 access-list   ra prefix-list}   other-config-flag   router-preference maximum   trusted-port}</code></p> <p><b>Example:</b></p> <pre>Device(config-nd-raguard)# default hop-limit</pre>	Restores a command to its default value.

	Command or Action	Purpose
<b>Step 11</b>	<b>do show ipv6 nd raguard policy <i>policy_name</i></b> <b>Example:</b> Device(config-nd-raguard)# <b>do show ipv6 nd raguard policy example_policy</b>	(Optional)—Displays the ND Guard Policy configuration without exiting the RA Guard policy configuration mode.

## How to Attach an IPv6 Router Advertisement Guard Policy to an Interface

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 Router Advertisement policy to an interface or to VLANs on the interface :

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 2</b>	<b>interface Interface_type <i>stack/module/port</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/1/4</b>	Specifies an interface type and identifier; enters the interface configuration mode.
<b>Step 3</b>	<b>ipv6 nd raguard [attach-policy <i>policy_name</i> [ vlan {<i>vlan_ids</i>   add <i>vlan_ids</i>   except <i>vlan_ids</i>   none   remove <i>vlan_ids</i>   all} ]   vlan [ {<i>vlan_ids</i>   add <i>vlan_ids</i>   except <i>vlan_ids</i>   none   remove <i>vlan_ids</i>   all} ]</b> <b>Example:</b> Device(config-if)# <b>ipv6 nd raguard attach-policy example_policy</b> or Device(config-if)# <b>ipv6 nd raguard attach-policy example_policy vlan 222,223,224</b> or Device(config-if)# <b>ipv6 nd raguard vlan 222, 223,224</b>	Attaches the Neighbor Discovery Inspection policy to the interface or the specified VLANs on that interface. The default policy is attached if the <b>attach-policy</b> option is not used.
<b>Step 4</b>	<b>do show running-config</b> <b>Example:</b> Device#(config-if)# <b>do show running-config</b>	Confirms that the policy is attached to the specified interface without exiting the configuration mode.

## How to Attach an IPv6 Router Advertisement Guard Policy to a Layer 2 EtherChannel Interface

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 Router Advertisement Guard Policy on an EtherChannel interface or VLAN:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 2</b>	<b>interface range</b> <i>Interface_name</i> <b>Example:</b> Device(config)# <b>interface Po11</b>	Specify the port-channel interface name assigned when the EtherChannel was created. Enters the interface range configuration mode.  <b>Tip</b> Enter the <b>do show interfaces summary</b> command for quick reference to interface names and types.
<b>Step 3</b>	<b>ipv6 nd rguard</b> [ <b>attach-policy</b> <i>policy_name</i> [ <b>vlan</b> { <i>vlan_ids</i>   <b>add</b> <i>vlan_ids</i>   <b>except</b> <i>vlan_ids</i>   <b>none</b>   <b>remove</b> <i>vlan_ids</i>   <b>all</b> } ]   <b>vlan</b> [ { <i>vlan_ids</i>   <b>add</b> <i>vlan_ids</i>   <b>except</b> <i>vlan_ids</i>   <b>none</b>   <b>remove</b> <i>vlan_ids</i>   <b>all</b> } ] ] <b>Example:</b> Device(config-if-range)# <b>ipv6 nd rguard attach-policy example_policy</b>  or  Device(config-if-range)# <b>ipv6 nd rguard attach-policy example_policy vlan 222,223,224</b>  or  Device(config-if-range)# <b>ipv6 nd rguard vlan 222, 223,224</b>	Attaches the RA Guard policy to the interface or the specified VLANs on that interface. The default policy is attached if the <b>attach-policy</b> option is not used.
<b>Step 4</b>	<b>do show running-config interface</b> <i>portchannel_interface_name</i> <b>Example:</b> Device#(config-if-range)# <b>do show running-config int po11</b>	Confirms that the policy is attached to the specified interface without exiting the configuration mode.

## How to Attach an IPv6 Router Advertisement Guard Policy to VLANs Globally

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 Router Advertisement policy to VLANs regardless of interface:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>vlan configuration <i>vlan_list</i></b> <b>Example:</b> Device(config)# <code>vlan configuration 335</code>	Specifies the VLANs to which the IPv6 RA Guard policy will be attached ; enters the VLAN interface configuration mode.
<b>Step 3</b>	<b>ipv6 dhcp guard [<i>attach-policy policy_name</i>]</b> <b>Example:</b> Device(config-vlan-config)# <code>ipv6 nd raguard attach-policy example_policy</code>	Attaches the IPv6 RA Guard policy to the specified VLANs across all switch and stack interfaces. The default policy is attached if the <b>attach-policy</b> option is not used.
<b>Step 4</b>	<b>do show running-config</b> <b>Example:</b> Device#(config-if)# <code>do show running-config</code>	Confirms that the policy is attached to the specified VLANs without exiting the configuration mode.

## How to Configure an IPv6 DHCP Guard Policy

Beginning in privileged EXEC mode, follow these steps to configure an IPv6 DHCP (DHCPv6) Guard policy:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters the global configuration mode.
<b>Step 2</b>	<b>[no]ipv6 dhcp guard policy <i>policy-name</i></b> <b>Example:</b> Device(config)# <code>ipv6 dhcp guard policy example_policy</code>	Specifies the DHCPv6 Guard policy name and enters DHCPv6 Guard Policy configuration mode.

	Command or Action	Purpose
Step 3	<p>[no]device-role {client   server}</p> <p><b>Example:</b></p> <pre>Device(config-dhcp-guard)# device-role server</pre>	<p>(Optional) Filters out DHCPv6 replies and DHCPv6 advertisements on the port that are not from a device of the specified role. Default is <b>client</b>.</p> <ul style="list-style-type: none"> <li>• <b>client</b>—Default value, specifies that the attached device is a client. Server messages are dropped on this port.</li> <li>• <b>server</b>—Specifies that the attached device is a DHCPv6 server. Server messages are allowed on this port.</li> </ul>
Step 4	<p>[no] match server access-list <i>ipv6-access-list-name</i></p> <p><b>Example:</b></p> <pre>;;Assume a preconfigured IPv6 Access List as follows: Device(config)# ipv6 access-list my_acls Device(config-ipv6-acl)# permit host FE80::A8BB:CCFF:FE01:F700 any  ;;configure DCHPv6 Guard to match approved access list. Device(config-dhcp-guard)# match server access-list my_acls</pre>	<p>(Optional). Enables verification that the advertised DHCPv6 server or relay address is from an authorized server access list (The destination address in the access list is 'any'). If not configured, this check will be bypassed. An empty access list is treated as a permit all.</p>
Step 5	<p>[no] match reply prefix-list <i>ipv6-prefix-list-name</i></p> <p><b>Example:</b></p> <pre>;;Assume a preconfigured IPv6 prefix list as follows: Device(config)# ipv6 prefix-list my_prefix permit 2001:0DB8::/64 le 128  ;; Configure DCHPv6 Guard to match prefix Device(config-dhcp-guard)# match reply prefix-list my_prefix</pre>	<p>(Optional) Enables verification of the advertised prefixes in DHCPv6 reply messages from the configured authorized prefix list. If not configured, this check will be bypassed. An empty prefix list is treated as a permit.</p>
Step 6	<p>[no]preference { max limit   min limit }</p> <p><b>Example:</b></p> <pre>Device(config-dhcp-guard)# preference max 250 Device(config-dhcp-guard)#preference min 150</pre>	<p>Configure <b>max</b> and <b>min</b> when <b>device-role</b> is <b>server</b> to filter DCHPv6 server advertisements by the server preference value. The defaults permit all advertisements.</p> <p><b>max limit</b>—(0 to 255) (Optional) Enables verification that the advertised preference (in preference option) is less than the specified limit. Default is 255. If not specified, this check will be bypassed.</p>

	Command or Action	Purpose
		<b>min limit</b> —(0 to 255) (Optional) Enables verification that the advertised preference (in preference option) is greater than the specified limit. Default is 0. If not specified, this check will be bypassed.
<b>Step 7</b>	<b>[no] trusted-port</b>  <b>Example:</b> Device(config-dhcp-guard)# <b>trusted-port</b>	(Optional) <b>trusted-port</b> —Sets the port to a trusted mode. No further policing takes place on the port.  <b>Note</b> If you configure a trusted port then the device-role option is not available.
<b>Step 8</b>	<b>default {device-role   trusted-port}</b>  <b>Example:</b> Device(config-dhcp-guard)# <b>default device-role</b>	(Optional) <b>default</b> —Sets a command to its defaults.
<b>Step 9</b>	<b>do show ipv6 dhcp guard policy policy_name</b>  <b>Example:</b> Device(config-dhcp-guard)# <b>do show ipv6 dhcp guard policy example_policy</b>	(Optional) Displays the configuration of the IPv6 DHCP guard policy without leaving the configuration submenu. Omitting the <i>policy_name</i> variable displays all DHCPv6 policies.

### Example of DHCPv6 Guard Configuration

```
enable
configure terminal
ipv6 access-list acl1
 permit host FE80::A8BB:CCFF:FE01:F700 any
ipv6 prefix-list abc permit 2001:0DB8::/64 le 128
ipv6 dhcp guard policy poll
 device-role server
 match server access-list acl1
 match reply prefix-list abc
 preference min 0
 preference max 255
 trusted-port
interface GigabitEthernet 0/2/0
 switchport
 ipv6 dhcp guard attach-policy poll vlan add 1
 vlan 1
 ipv6 dhcp guard attach-policy poll
show ipv6 dhcp guard policy poll
```

## How to Attach an IPv6 DHCP Guard Policy to an Interface or a VLAN on an Interface

Beginning in privileged EXEC mode, follow these steps to configure IPv6 Binding Table Content :

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 2</b>	<b>interface</b> Interface_type <i>stack/module/port</i> <b>Example:</b> Device(config)# <b>interface</b> <b>gigabitethernet 1/1/4</b>	Specifies an interface type and identifier; enters the interface configuration mode.
<b>Step 3</b>	<b>ipv6 dhcp guard</b> [ <b>attach-policy</b> <i>policy_name</i> [ <b>vlan</b> { <i>vlan_ids</i>   <b>add</b> <i>vlan_ids</i>   <b>except</b> <i>vlan_ids</i>   <b>none</b>   <b>remove</b> <i>vlan_ids</i>   <b>all</b> } ]   <b>vlan</b> [ { <i>vlan_ids</i>   <b>add</b> <i>vlan_ids</i>   <b>except</b> <i>vlan_ids</i>   <b>none</b>   <b>remove</b> <i>vlan_ids</i>   <b>all</b> } ] ] <b>Example:</b> Device(config-if)# <b>ipv6 dhcp guard</b> <b>attach-policy example_policy</b>  or Device(config-if)# <b>ipv6 dhcp guard</b> <b>attach-policy example_policy vlan</b> <b>222,223,224</b>  or Device(config-if)# <b>ipv6 dhcp guard vlan</b> <b>222, 223,224</b>	Attaches the DHCP Guard policy to the interface or the specified VLANs on that interface. The default policy is attached if the <b>attach-policy</b> option is not used.
<b>Step 4</b>	<b>do show running-config interface</b> Interface_type <i>stack/module/port</i> <b>Example:</b> Device#(config-if)# <b>do show</b> <b>running-config gig 1/1/4</b>	Confirms that the policy is attached to the specified interface without exiting the configuration mode.

## How to Attach an IPv6 DHCP Guard Policy to a Layer 2 EtherChannel Interface

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 DHCP Guard policy on an EtherChannel interface or VLAN:



## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters the global configuration mode.
<b>Step 2</b>	<b>interface range</b> <i>Interface_name</i> <b>Example:</b> Device(config)# <code>interface Po11</code>	Specify the port-channel interface name assigned when the EtherChannel was created. Enters the interface range configuration mode.  <b>Tip</b> Enter the <b>do show interfaces summary</b> command for quick reference to interface names and types.
<b>Step 3</b>	<b>ipv6 dhcp guard</b> [ <b>attach-policy</b> <i>policy_name</i> [ <b>vlan</b> { <i>vlan_ids</i>   <b>add</b> <i>vlan_ids</i>   <b>except</b> <i>vlan_ids</i>   <b>none</b>   <b>remove</b> <i>vlan_ids</i>   <b>all</b> } ]   <b>vlan</b> [ { <i>vlan_ids</i>   <b>add</b> <i>vlan_ids</i>   <b>except</b> <i>vlan_ids</i>   <b>none</b>   <b>remove</b> <i>vlan_ids</i>   <b>all</b> } ] ] <b>Example:</b> Device(config-if-range)# <code>ipv6 dhcp guard attach-policy example_policy</code>  or  Device(config-if-range)# <code>ipv6 dhcp guard attach-policy example_policy vlan 222,223,224</code>  or  Device(config-if-range)# <code>ipv6 dhcp guard vlan 222, 223,224</code>	Attaches the DHCP Guard policy to the interface or the specified VLANs on that interface. The default policy is attached if the <b>attach-policy</b> option is not used.
<b>Step 4</b>	<b>do show running-config interface</b> <i>portchannel_interface_name</i> <b>Example:</b> Device#(config-if-range)# <code>do show running-config int po11</code>	Confirms that the policy is attached to the specified interface without exiting the configuration mode.

## How to Attach an IPv6 DHCP Guard Policy to VLANs Globally

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 DHCP Guard policy to VLANs across multiple interfaces:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters the global configuration mode.
<b>Step 2</b>	<b>vlan configuration <i>vlan_list</i></b> <b>Example:</b> Device(config)# <code>vlan configuration 334</code>	Specifies the VLANs to which the IPv6 Snooping policy will be attached ; enters the VLAN interface configuration mode.
<b>Step 3</b>	<b>ipv6 dhcp guard [attach-policy <i>policy_name</i>]</b> <b>Example:</b> Device(config-vlan-config)# <code>ipv6 dhcp guard attach-policy example_policy</code>	Attaches the IPv6 Neighbor Discovery policy to the specified VLANs across all switch and stack interfaces. The default policy is attached if the <b>attach-policy</b> option is not used. The default policy is, device-role <b>client</b> , <b>no</b> trusted-port.
<b>Step 4</b>	<b>do show running-config</b> <b>Example:</b> Device#(config-if)# <code>do show running-config</code>	Confirms that the policy is attached to the specified VLANs without exiting the configuration mode.

## How to Configure IPv6 Source Guard

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters the global configuration mode.
<b>Step 3</b>	<b>[no] ipv6 source-guard policy <i>policy_name</i></b> <b>Example:</b> Device(config)# <code>ipv6 source-guard policy example_policy</code>	Specifies the IPv6 Source Guard policy name and enters IPv6 Source Guard policy configuration mode.
<b>Step 4</b>	<b>[deny global-autoconf] [permit link-local]</b> <b>[default{...}] [exit] [no{...}]</b>	(Optional) Defines the IPv6 Source Guard policy.

	Command or Action	Purpose
	<b>Example:</b> Device(config-sisf-sourceguard)# <b>deny global-autoconf</b>	<ul style="list-style-type: none"> <li>• <b>deny global-autoconf</b>—Denies data traffic from auto-configured global addresses. This is useful when all global addresses on a link are DHCP-assigned and the administrator wants to block hosts with self-configured addresses to send traffic.</li> <li>• <b>permit link-local</b>—Allows all data traffic that is sourced by a link-local address.</li> </ul> <p><b>Note</b> Trusted option under source guard policy is not supported.</p>
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-sisf-sourceguard)# <b>end</b>	Exits out of IPv6 Source Guard policy configuration mode.
<b>Step 6</b>	<b>show ipv6 source-guard policy <i>policy_name</i></b> <b>Example:</b> Device# <b>show ipv6 source-guard policy example_policy</b>	Shows the policy configuration and all the interfaces where the policy is applied.

**What to do next**

Apply the IPv6 Source Guard policy to an interface.

## How to Attach an IPv6 Source Guard Policy to an Interface

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 3</b>	<b>interface</b> Interface_type <i>stack/module/port</i> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/1/4</b>	Specifies an interface type and identifier; enters the interface configuration mode.

	Command or Action	Purpose
<b>Step 4</b>	<b>ipv6 source-guard [ attach-policy &lt;policy_name&gt; ]</b>  <b>Example:</b> Device(config-if)# <b>ipv6 source-guard attach-policy example_policy</b>	Attaches the IPv6 Source Guard policy to the interface. The default policy is attached if the <b>attach-policy</b> option is not used.
<b>Step 5</b>	<b>show ipv6 source-guard policy policy_name</b>  <b>Example:</b> Device#(config-if) # <b>show ipv6 source-guard policy example_policy</b>	Shows the policy configuration and all the interfaces where the policy is applied.

## How to attach an IPv6 Source Guard Policy to a Layer 2 EtherChannel Interface

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 3</b>	<b>interface port-channel port-channel-number</b>  <b>Example:</b> Device (config)# <b>interface Po4</b>	Specifies an interface type and port number and places the switch in the port channel configuration mode.
<b>Step 4</b>	<b>ipv6 source-guard [ attach-policy &lt;policy_name&gt; ]</b>  <b>Example:</b> Device(config-if) # <b>ipv6 source-guard attach-policy example_policy</b>	Attaches the IPv6 Source Guard policy to the interface. The default policy is attached if the <b>attach-policy</b> option is not used.
<b>Step 5</b>	<b>show ipv6 source-guard policy policy_name</b>  <b>Example:</b> Device(config-if) # <b>show ipv6 source-guard policy example_policy</b>	Shows the policy configuration and all the interfaces where the policy is applied.

# How to Configure IPv6 Prefix Guard



**Note** To allow routing protocol control packets sourced by a link-local address when prefix guard is applied, enable the permit link-local command in the source-guard policy configuration mode.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>[ no ] ipv6 source-guard policy</b> <i>source-guard-policy</i> <b>Example:</b> Device (config)# <b>ipv6 source-guard policy</b> <b>my_snooping_policy</b>	Defines an IPv6 source-guard policy name and enters switch integrated security features source-guard policy configuration mode.
<b>Step 4</b>	<b>[ no ] validate address</b> <b>Example:</b> Device (config-sisf-sourceguard)# <b>no</b> <b>validate address</b>	Disables the validate address feature and enables the IPv6 prefix guard feature to be configured.
<b>Step 5</b>	<b>validate prefix</b> <b>Example:</b> Device (config-sisf-sourceguard)# <b>validate prefix</b>	Enables IPv6 source guard to perform the IPv6 prefix-guard operation.
<b>Step 6</b>	<b>exit</b> <b>Example:</b> Device (config-sisf-sourceguard)# <b>exit</b>	Exits switch integrated security features source-guard policy configuration mode and returns to privileged EXEC mode.
<b>Step 7</b>	<b>show ipv6 source-guard policy</b> <i>[source-guard-policy]</i> <b>Example:</b>	Displays the IPv6 source-guard policy configuration.

	Command or Action	Purpose
	Device # <code>show ipv6 source-guard policy policy1</code>	

## How to Attach an IPv6 Prefix Guard Policy to an Interface

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters the global configuration mode.
<b>Step 3</b>	<b>interface</b> <i>Interface_type stack/module/port</i> <b>Example:</b> Device(config)# <code>interface gigabitethernet 1/1/4</code>	Specifies an interface type and identifier; enters the interface configuration mode.
<b>Step 4</b>	<b>ipv6 source-guard attach-policy</b> <i>policy_name</i> <b>Example:</b> Device(config-if)# <code>ipv6 source-guard attach-policy example_policy</code>	Attaches the IPv6 Source Guard policy to the interface. The default policy is attached if the <b>attach-policy</b> option is not used.
<b>Step 5</b>	<b>show ipv6 source-guard policy</b> <i>policy_name</i> <b>Example:</b> Device(config-if)# <code>show ipv6 source-guard policy example_policy</code>	Shows the policy configuration and all the interfaces where the policy is applied.

## How to attach an IPv6 Prefix Guard Policy to a Layer 2 EtherChannel Interface

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 3</b>	<b>interface port-channel <i>port-channel-number</i></b> <b>Example:</b> Device (config)# <b>interface Po4</b>	Specifies an interface type and port number and places the switch in the port channel configuration mode.
<b>Step 4</b>	<b>ipv6 source-guard [attach-policy &lt;policy_name&gt; ]</b> <b>Example:</b> Device(config-if)# <b>ipv6 source-guard attach-policy example_policy</b>	Attaches the IPv6 Source Guard policy to the interface. The default policy is attached if the <b>attach-policy</b> option is not used.
<b>Step 5</b>	<b>show ipv6 source-guard policy <i>policy_name</i></b> <b>Example:</b> Device(config-if)# <b>show ipv6 source-guard policy example_policy</b>	Shows the policy configuration and all the interfaces where the policy is applied.

## Configuration Examples for IPv6 First Hop Security

### Examples: How to attach an IPv6 Source Guard Policy to a Layer 2 EtherChannel Interface

The following example shows how to attach an IPv6 Source Guard Policy to a Layer 2 EtherChannel Interface:

```
Switch# configure terminal
Switch(config)# ipv6 source-guard policy POL
Switch(config-sisf-sourceguard) # validate address
switch(config-sisf-sourceguard) # exit
Switch(config)# interface Po4
Switch(config)# ipv6 snooping
Switch(config-if)# ipv6 source-guard attach-policy POL
Switch(config-if)# exit
switch(config)#
```

### Examples: How to attach an IPv6 Prefix Guard Policy to a Layer 2 EtherChannel Interface

The following example shows how to attach an IPv6 Prefix Guard Policy to a Layer 2 EtherChannel Interface:

```
Switch# configure terminal
Switch(config)# ipv6 source-guard policy POL
Switch (config-sisf-sourceguard) # no validate address
Switch((config-sisf-sourceguard) # validate prefix
Switch(config)# interface Po4
```

```
Switch(config-if)# ipv6 snooping
Switch(config-if)# ipv6 source-guard attach-policy POL
```

## Additional References

### Related Documents

Related Topic	Document Title
Implementing IPv6 Addressing and Basic Connectivity	<a href="http://www.cisco.com/.../ip6fundr.html">http://www.cisco.com/.../ip6fundr.html</a>
IPv6 network management and security topics	IPv6 Configuration Library, Cisco IOS XE Release 3SE (Catalyst 3850 Switches) <a href="http://www.cisco.com/.../ip6lib/3850-3850.html">http://www.cisco.com/.../ip6lib/3850-3850.html</a>
IPv6 Command Reference	IPv6 Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches) <a href="http://www.cisco.com/.../ip6comref/3850.html">http://www.cisco.com/.../ip6comref/3850.html</a>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>





## CHAPTER 115

# Configuring SISF-Based Device Tracking

- [Information About SISF-Based Device Tracking, on page 2179](#)
- [How to Configure SISF-Based Device Tracking, on page 2185](#)
- [Configuration Examples for SISF-Based Device Tracking, on page 2192](#)
- [Feature History and Information for SISF-Based Device Tracking, on page 2195](#)

## Information About SISF-Based Device Tracking

### Overview of SISF-Based Device Tracking

The Switch Integrated Security Features based (SISF-based) device tracking feature is part of the suite of first-hop security features.

The main role of the feature is to track the presence, location, and movement of end-nodes in the network. SISF snoops traffic received by the switch, extracts device identity (MAC and IP address), and stores them in a binding table. Many features, such as, IEEE 802.1X, web authentication, Cisco TrustSec and LISP etc., depend on the accuracy of this information to operate properly.

SISF-based device tracking supports both IPv4 and IPv6.

Even with the introduction of SISF-based device tracking, the legacy device tracking CLI (IP Device Tracking (IPDT) and IPv6 Snooping CLI) continues to be available. When you bootup the switch, the set of commands that is available depends on existing configuration, and only one of the following is available:

- SISF-based device tracking CLI, or
- IPDT and IPv6 Snooping CLI



**Note** The IPDT and IPv6 Snooping commands are deprecated, but continue to be available. We recommend that you upgrade to SISF-based device tracking.

If you are using the IPDT and IPv6 Snooping CLI and want to migrate to SISF-based device tracking, see *Migrating from legacy IPDT and IPv6 Snooping to SISF-Based Device Tracking*, for more information.

SISF-based device tracking can be enabled manually (by using **device-tracking** commands), or programmatically (which is the case when providing device tracking services to other features).

## Options to Enable SISF-Based Device Tracking

SISF-Based device tracking is disabled by default.

You can enable it by defining a device tracking policy and attaching the policy to a specific target.




---

**Note** The target could be an interface or a VLAN.

---

### Manually Enabling SISF-Based Device Tracking

- Option 1: Apply the **default** device tracking policy to a target.

Enter the **device-tracking** command in the interface configuration mode or in the VLAN configuration mode. The system then attaches the **default** policy it to the interface or VLAN.




---

**Note** The **default** policy is a built-in policy with default settings; you cannot change any of the attributes of the **default** policy. In order to be able to configure device tracking policy attributes you must create a custom policy. See *Option 2: Create a custom policy with custom settings*.

---

- Option 2: Create a custom policy with custom settings.

Enter the device-tracking policy command in global configuration mode and enter a custom policy name. The system creates a policy with the name you specify. You can then configure the available settings, in the device tracking configuration mode (config-device-tracking), and attach the policy to a specified target.

### Programmatically Enabling SISF-Based Device Tracking

Some features rely on device tracking and utilize the trusted database of binding entries that SISF-based device tracking builds and maintains. These features, also called device tracking clients, enable device tracking programmatically (create and attach the device tracking policy).




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**Note** The exceptions here are IEEE 802.1X, web authentication, Cisco TrustSec, and IP Source Guard (IPSG) - they also rely on device tracking, but they do not enable it. For these device tracking clients, you must enter the **ip dhcp snooping vlan *vlan*** command, to programmatically enable device tracking on a particular target.

---

Note the following about programmatically enabling SISF-based device tracking:

- A device tracking client *requires* device tracking to be enabled.

There are several device tracking clients, therefore, multiple programmatic policies could be created. The settings of each policy differ depending on the device tracking client that creates the policy.

- The policy that is created, and its settings, are system-defined.

Configurable policy attributes are available in the device tracking configuration mode (config-device-tracking) and vary from one release to another. If you try to modify an attribute that is not configurable, the configuration change is rejected and an error message is displayed.

For release-specific information about programmatically created policies, see *Programmatically Enabling SISF-Based Device Tracking in Cisco IOS XE <release name> <release number>* in the required version of the document.

## Migrating from Legacy Commands to SISF-Based Device-Tracking Commands

### Migrating from Legacy IPDT and IPv6 Snooping to SISF-Based Device Tracking

Starting with Cisco IOS XE Denali 16.1.1, the existing IPv6 snooping and IP Device Tracking (IPDT) commands have corresponding SISF-based device-tracking commands that allow you to apply your configuration to both IPv4 and IPv6 address families.

After you have upgraded from a Cisco IOS XE 3.x.x release to a Cisco IOS XE 16.x.x release, enter the **device-tracking upgrade-cli** to convert legacy IPDT and IPv6 Snooping commands to SISF-based device tracking commands. After you run the command, only the new device-tracking commands are available on your device and the legacy commands are not supported.

Based on the legacy configuration that exists on your device, the **device-tracking upgrade-cli** command upgrades your CLI differently. Consider the following configuration scenarios and the corresponding migration results before you migrate your existing configuration.



---

**Note** You cannot configure a mix of the old IPDT and IPv6 snooping CLI with the new SISF-based device-tracking CLI.

---

#### Only IPDT Configuration Exists

If your device has only IPDT configuration, running the **device-tracking upgrade-cli** command converts the configuration to use the new SISF policy that is created and attached to the interface. You can then update this SISF policy.

If you continue to use the legacy commands, this restricts you to operate in a legacy mode where only the legacy IPDT and IPv6 snooping commands are available on the device.

#### Only IPv6 Snooping Configuration Exists

On a device with existing IPv6 snooping configuration, the old IPv6 Snooping commands are available for further configuration. The following options are available:

- (Recommended) Use the **device-tracking upgrade-cli** command to convert all your legacy configuration to the new SISF-based device tracking commands. After conversion, only the new device tracking commands will work on your device.
- Use the legacy IPv6 Snooping commands for your future configuration and do not run the **device-tracking upgrade-cli** command. With this option, only the legacy IPv6 Snooping commands are available on your device, and you cannot use the new SISF-based device tracking CLI commands.

### Both IPDT and IPv6 Snooping Configuration Exist

On a device that has both legacy IPDT configuration and IPv6 snooping configuration, you can convert legacy commands to the SISF-based device tracking CLI commands. However, note that only one snooping policy can be attached to an interface, and the IPv6 snooping policy parameters override the IPDT settings.



**Note** If you do not migrate to the new SISF-based commands and continue to use the legacy IPv6 snooping or IPDT commands, your IPv4 device tracking configuration information may be displayed in the IPv6 snooping commands, as the SISF-based device tracking feature handles both IPv4 and IPv6 configuration. To avoid this, we recommend that you convert your legacy configuration to SISF-based device tracking commands.

### No IPDT or IPv6 Snooping Configuration Exists

If your device has no legacy IP Device Tracking or IPv6 Snooping configurations, you can use only the new SISF-based device tracking commands for all your future configuration. The legacy IPDT commands and IPv6 snooping commands are not available.



**Note** Starting from Cisco IOS XE Denali 16.3.1, the **ip dhcp snooping vlan** *vlan* command creates a device tracking policy programmatically, to support the IEEE 802.1X, web authentication, Cisco TrustSec and IPSG features. The programmatically created policy tracks both IPv4 and IPv6 clients. Ensure that this command is configured, if you are using any of the aforementioned features.

## IPDT, IPv6 Snooping, and SISF-Based Device Tracking CLI Compatibility

Table [Table 167: IPDT → IPv6 Snooping Commands, on page 2182](#) displays legacy IPDT and the IPv6 snooping commands they are converted to. (The commands listed here are applicable if you have not upgraded to SISF-based device-tracking).

Table [Table 168: IPDT → SISF Commands, on page 2183](#) displays legacy IPDT and the SISF-based device-tracking commands. (The commands listed here are applicable if you have upgraded to SISF-based device-tracking, with the **device-tracking upgrade-cli** command.)

**Table 167: IPDT → IPv6 Snooping Commands**

Legacy IP Device Tracking (IPDT)	IPv6 Snooping Command (Until Cisco IOS XE Denali 16.3.6 and Cisco IOS XE Everest 16.5.x)	IPv6 Snooping Command (Starting from Cisco IOS XE Denali 16.3.7 and all later releases except Cisco IOS XE Everest 16.5.x).
<b>ip device tracking probe count</b>	Set to the default value, and cannot be changed.	Set to the default value, and cannot be changed.
<b>ip device tracking probe delay</b>	<b>ipv6 neighbor binding reachable-lifetime</b>  <b>Attention</b> Incorrect system conversion. <sup>26</sup>	Set to the default value, and cannot be changed

Legacy IP Device Tracking (IPDT)	IPv6 Snooping Command (Until Cisco IOS XE Denali 16.3.6 and Cisco IOS XE Everest 16.5.x)	IPv6 Snooping Command (Starting from Cisco IOS XE Denali 16.3.7 and all later releases except Cisco IOS XE Everest 16.5.x).
<b>ip device tracking probe interval</b>	<b>ipv6 snooping tracking retry-interval</b>  <b>Attention</b> Incorrect system conversion. <a href="#">27</a>	<b>ipv6 neighbor binding reachable-lifetime</b>
<b>ip device tracking probe use-svi</b>	Set to the default behavior, and cannot be changed.	Set to the default behavior, and cannot be changed.
<b>ip device tracking probe auto-source [ fallback host-ip-address subnet-mask ] [ override ]</b>	<b>ipv6 neighbor tracking auto-source [ fallback host-ip-address subnet-mask ] [ override ]</b>	No change, same as Cisco IOS XE Denali 16.3.6
<b>ip device tracking trace-buffer</b>	Not supported	No change, same as Cisco IOS XE Denali 16.3.6
<b>ip device tracking maximum n</b>	<b>ipv6 snooping policy IPDT_MAX_n [ limit address-count ]</b>	No change, same as Cisco IOS XE Denali 16.3.6
<b>ip device tracking maximum 0</b>	Not supported	No change, same as Cisco IOS XE Denali 16.3.6
<b>clear ip device tracking all</b>	Not supported	No change, same as Cisco IOS XE Denali 16.3.6

<sup>26</sup> Until Cisco IOS XE Denali 16.3.6 and in Cisco IOS XE Everest 16.5.x, the system incorrectly converts the **ip device tracking probe delay** command to **ipv6 neighbor binding reachable-lifetime**. Starting from Cisco IOS XE Denali 16.3.7 (except Cisco IOS XE Everest 16.5.x), this is corrected to be set to the default value and cannot be changed.

<sup>27</sup> Until Cisco IOS XE Denali 16.3.6 and in Cisco IOS XE Everest 16.5.x, the system incorrectly converts the **ip device tracking probe interval** command to **ipv6 snooping tracking retry-interval**. Starting from Cisco IOS XE Denali 16.3.7 (except in Cisco IOS XE Everest 16.5.x), this is correctly converted to **ipv6 neighbor binding reachable-lifetime**.

Table 168: IPDT → SISF Commands

Legacy IPDT	SISF-Based Device-Tracking After SISF Conversion (Until Cisco IOS XE Denali 16.3.6 and in Cisco IOS XE Everest 16.5.1a )	SISF-Based Device-Tracking After SISF Conversion (Starting from Cisco IOS XE Denali 16.3.7 and all later releases except Cisco IOS XE Everest 16.5.1a).
<b>ip device tracking probe count</b>	Set to the default value, and cannot be changed.	Set to the default value, and cannot be changed.

Legacy IPDT	SISF-Based Device-Tracking After SISF Conversion (Until Cisco IOS XE Denali 16.3.6 and in Cisco IOS XE Everest 16.5.1a )	SISF-Based Device-Tracking After SISF Conversion (Starting from Cisco IOS XE Denali 16.3.7 and all later releases except Cisco IOS XE Everest 16.5.1a).
<b>ip device tracking probe delay</b>	<b>device-tracking binding reachable-lifetime</b> <b>Attention</b> Incorrect system conversion. <sup>28</sup>	Set to the default value, and cannot be changed.
<b>ip device tracking probe interval</b>	<b>device-tracking tracking retry-interval</b> <b>Attention</b> Incorrect system conversion. <sup>29</sup>	<b>device-tracking binding reachable-lifetime</b>
<b>ip device tracking probe use-svi</b>	Set to the default behaviour and cannot be changed.	No change, same as Cisco IOS XE Denali 16.3.6
<b>ip device tracking probe auto-source [ fallback host-ip-address subnet-mask ] [override]</b>	<b>device-tracking tracking auto-source [ fallback host-ip-address subnet-mask ] [override]</b>	No change, same as Cisco IOS XE Denali 16.3.6
<b>ip device tracking trace-buffer</b>	Not supported	No change, same as Cisco IOS XE Denali 16.3.6
<b>ip device tracking maximum n</b>	<b>device-tracking snooping policy IPDT_MAX_n [limit address-count]</b>	No change, same as Cisco IOS XE Denali 16.3.6
<b>ip device tracking maximum 0</b>	Not supported	No change, same as Cisco IOS XE Denali 16.3.6
<b>clear ip device tracking all</b>	Not supported	No change, same as Cisco IOS XE Denali 16.3.6

<sup>28</sup> Until Cisco IOS XE Denali 16.3.6 and in Cisco IOS XE Everest 16.5.x, the system incorrectly converts the **ip device tracking probe delay** command to **device-tracking binding reachable-lifetime**. Starting from Cisco IOS XE Denali 16.3.7 (except in Cisco IOS XE Everest 16.5.x), this is corrected to be set to the default value and cannot be changed.

<sup>29</sup> Until Cisco IOS XE Denali 16.3.6 and in Cisco IOS XE Everest 16.5.x, the system incorrectly converts the **ip device tracking probe interval** command to **device-tracking tracking retry-interval**. Starting from Cisco IOS XE Denali 16.3.7 (except in Cisco IOS XE Everest 16.5.x), this is correctly converted to **device-tracking binding reachable-lifetime**.

# How to Configure SISF-Based Device Tracking

## Manually Enabling SISF-Based Device Tracking

### Applying the Default Device Tracking Policy to a Target

Beginning in privileged EXEC mode, follow these steps to apply the default device tracking policy to an interface or VLAN:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 2</b>	Specify an interface or a VLAN <ul style="list-style-type: none"> <li>• <b>interface</b> <i>interface</i></li> <li>• <b>vlan configuration</b> <i>vlan_list</i></li> </ul> <b>Example:</b> Device(config)# <b>interface</b> gigabitethernet 1/1/4 OR Device(config)# <b>vlan configuration</b> 333	<b>interface</b> <i>type number</i> —Specifies the interface and enters the interface configuration mode. The device tracking policy will be attached to the specified interface.  <b>vlan configuration</b> <i>vlan_list</i> —Specifies the VLANs and enters the VLAN feature configuration mode. The device tracking policy will be attached to the specified VLAN.
<b>Step 3</b>	<b>device-tracking</b>  <b>Example:</b> Device(config-if)# <b>device-tracking</b> OR Device(config-vlan-config)# <b>device-tracking</b>	Enables SISF-based device tracking and attaches the default policy it to the interface or VLAN.  The default policy is a built-in policy with default settings; none of the attributes of the default policy can be changed.
<b>Step 4</b>	<b>exit</b>  <b>Example:</b> Device(config-if)# <b>exit</b> OR Device(config-vlan-config)# <b>exit</b>	Exits configuration mode.
<b>Step 5</b>	<b>show device-tracking policy</b> <i>policy-name</i>  <b>Example:</b> Device# <b>show device-tracking policy</b> <b>default</b>	Displays device-tracking policy configuration, and all the targets it is applied to.

## Creating a Custom Device Tracking Policy with Custom Settings

Beginning in privileged EXEC mode, follow these steps to create and configure a device tracking policy:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 2</b>	<b>[no] device-tracking policy <i>policy-name</i></b> <b>Example:</b> Device (config)# <b>device-tracking policy example_policy</b>	Creates the policy and enters the device-tracking configuration mode.
<b>Step 3</b>	<b>[data-glean   default   destination-glean   device-role   distribution-switch   exit   limit   no   prefix-glean   protocol   security-level   tracking   trusted-port   vpc]</b> <b>Example:</b> Device (config-device-tracking)# <b>destination-glean log-only</b>	Enter the question mark (?) at the system prompt to obtain a list of available options in this mode. You can configure the following for both IPv4 and IPv6: <ul style="list-style-type: none"> <li>• (Optional) <b>data-glean</b>—Enables learning of addresses from a data packet snooped from a source inside the network and populates the binding table with the data traffic source address. Enter one of these options:               <ul style="list-style-type: none"> <li>• <b>log-only</b>—Generates a syslog message upon data packet notification</li> <li>• <b>recovery</b>—Uses a protocol to enable binding table recovery. Enter <b>NDP</b> or <b>DHCP</b>.</li> </ul> </li> <li>• (Optional) <b>default</b>—Sets the policy attribute to its default value. You can set these policy attributes to their default values: <b>data-glean</b>, <b>destination-glean</b>, <b>device-role</b>, <b>limit</b>, <b>prefix-glean</b>, <b>protocol</b>, <b>security-level</b>, <b>tracking</b>, <b>trusted-port</b>.</li> <li>• (Optional) <b>destination-glean</b>—Populates the binding table by gleaned data traffic destination address. Enter one of these options:               <ul style="list-style-type: none"> <li>• <b>log-only</b>—Generates a syslog message upon data packet notification</li> <li>• <b>recovery</b>—Uses a protocol to enable binding table recovery. Enter <b>DHCP</b>.</li> </ul> </li> </ul>



	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• (Optional) <b>device-role</b>—Sets the role of the device attached to the port. It can be a node or a switch. Enter one of these options: <ul style="list-style-type: none"> <li>• <b>node</b>—Configures the attached device as a node. This is the default option.</li> <li>• <b>switch</b>—Configures the attached device as a switch.</li> </ul> </li> <li>• (Optional) <b>distribution-switch</b>—Although visible on the CLI, this option is not supported. Any configuration settings you make will not take effect.</li> <li>• <b>exit</b>—Exits the device-tracking policy configuration mode.</li> <li>• <b>limit address-count</b>—Specifies an address count limit per port. The range is 1 to 32000.</li> <li>• <b>no</b>—Negates the command or sets it to defaults.</li> <li>• (Optional) <b>prefix-glean</b>—Enables learning of prefixes from either IPv6 Router Advertisements or from DHCP-PD. You have the following option: <ul style="list-style-type: none"> <li>• (Optional) <b>only</b>—Gleans only prefixes and not host addresses.</li> </ul> </li> <li>• (Optional) <b>protocol</b>—Sets the protocol to glean; by default, all are gleaned. Enter one of these options: <ul style="list-style-type: none"> <li>• <b>arp [prefix-list name]</b>—Gleans addresses in ARP packets. Optionally, enter the name of prefix-list that is to be matched.</li> <li>• <b>dhcp4 [prefix-list name]</b>—Glean addresses in DHCPv4 packets. Optionally, enter the name of prefix-list that is to be matched.</li> <li>• <b>dhcp6 [prefix-list name]</b>—Glean addresses in DHCPv6 packets. Optionally, enter the name of prefix-list that is to be matched.</li> </ul> </li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>ndp</b> [<b>prefix-list name</b>]—Glean addresses in NDP packets. Optionally, enter the name of prefix-list that is to be matched.</li> <li>• <b>udp</b> [<b>prefix-list name</b>]—Although visible on the CLI, this option is not supported. Any configuration settings you make will not take effect.</li> <li>• (Optional) <b>security-level</b>—Specifies the level of security enforced by the feature. Enter one of these options: <ul style="list-style-type: none"> <li>• <b>glean</b>—Gleans addresses passively.</li> <li>• <b>guard</b>—Inspects and drops un-authorized messages. This is the default.</li> <li>• <b>inspect</b>—Gleans and validates messages.</li> </ul> </li> <li>• (Optional) <b>tracking</b>—Specifies a tracking option. Enter one of these options: <ul style="list-style-type: none"> <li>• <b>disable</b> [<b>stale-lifetime</b> [<i>1-86400-seconds</i>   <b>infinite</b>] ] —Turns off device-tracking.  Optionally, you can enter the duration for which the entry is kept inactive before deletion, or keep it permanently inactive.</li> <li>• <b>enable</b> [<b>reachable-lifetime</b> [<i>1-86400-seconds</i>   <b>infinite</b>] ] —Turns on device-tracking.  Optionally, you can enter the duration for which the entry is kept reachable, or keep it permanently reachable.</li> </ul> </li> <li>• (Optional) <b>trusted-port</b>—Sets up a trusted port. Disables the guard on applicable targets. Bindings learned through a trusted port have preference over bindings learned through any other port. A trusted port is given preference in case of a collision while making an entry in the table.</li> <li>• (Optional) <b>vpc</b>—Although visible on the CLI, this option is not supported. Any</li> </ul>

	Command or Action	Purpose
		configuration settings you make will not take effect.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config-device-tracking)# <b>exit</b>	Exits configuration mode.
<b>Step 5</b>	<b>show device-tracking policy</b> <i>policy-name</i> <b>Example:</b> Device# <b>show device-tracking policy</b> <b>example_policy</b>	Displays the device-tracking policy configuration.

**What to do next**

Attach the policy to an interface or VLAN.

**Attaching a Device Tracking Policy to an Interface**

Beginning in privileged EXEC mode, follow these steps to attach a device tracking policy to an interface:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 2</b>	<b>interface</b> <i>interface</i> <b>Example:</b> Device(config)# <b>interface gigabitethernet</b> <b>1/1/4</b>	Specifies an interface and enters the interface configuration mode.
<b>Step 3</b>	<b>[no] device-tracking attach-policy</b> <i>policy name</i> <b>Example:</b> Device(config-if)# <b>device-tracking</b> <b>attach-policy example_policy</b>	Attaches the device tracking policy to the interface.  <b>Note</b> SISF based device-tracking policies can be disabled only if they are custom policies. Programmatically created policies can be removed only if the corresponding device-tracking client feature configuration is removed.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device# <b>end</b>	Returns to the privileged EXEC mode.

	Command or Action	Purpose
<b>Step 5</b>	<b>show device-tracking policies [ interface interface ]</b>  <b>Example:</b> Device# <b>show device-tracking policies interface gigabitethernet 1/1/4</b>	Displays policies that match the specified interface type and number.

## Attaching a Device Tracking Policy to a VLAN

Beginning in privileged EXEC mode, follow these steps to attach a device-tracking policy to VLANs across multiple interfaces:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 2</b>	<b>vlan configuration vlan_list</b>  <b>Example:</b> Device(config)# <b>vlan configuration 333</b>	Specifies the VLANs to which the device tracking policy will be attached; enters the VLAN interface configuration mode.
<b>Step 3</b>	<b>[no] device-tracking attach-policy policy_name</b>  <b>Example:</b> Device(config-vlan-config)# <b>device-tracking attach-policy example_policy</b>	Attaches the device tracking policy to the specified VLANs across all switch interfaces.  <b>Note</b> SISF based device-tracking policies can be disabled only if they are custom policies. Programmatically created policies can be removed only if the corresponding device-tracking client feature configuration is removed.
<b>Step 4</b>	<b>do show device-tracking policies vlan vlan-ID</b>  <b>Example:</b> Device(config-vlan-config)# <b>do show device-tracking policies vlan 333</b>	Verifies that the policy is attached to the specified VLAN, without exiting the VLAN interface configuration mode.

## Programmatically Enabling SIFS-Based Device Tracking in Cisco IOS XE Denali 16.3.x

Table 169: Programmatically Enabling SIFS-Based Device Tracking in Cisco IOS XE Denali 16.3.x

Device tracking client features that can enable SIFS-based device tracking	In this release, you can programmatically enable SIFS-based device tracking for these features:  IEEE 802.1X, web authentication, Cisco TrustSec, wireless, and IPSG features: enter the <b>ip dhcp snooping vlan</b> <i>vlan</i> command.
Policy Name	WL_DEVICE_TRACKING_DHCP ((automatically attached to the VLAN))
User Options	<ul style="list-style-type: none"> <li>• Policy settings cannot be modified.</li> <li>• The programmatically created policy cannot be replaced by another policy</li> <li>• Only one device-tracking policy can be attached to the same interface or VLAN</li> <li>• The policy cannot be removed unless the device tracking client feature configuration is removed.</li> <li>• When a device-tracking policy is attached to an interface under a VLAN, the policy settings on the interface take precedence over those on its VLAN; exceptions here are the values for <b>limit address-count for IPv4 per mac</b> and <b>limit address-count for IPv6 per mac</b>, which are aggregated from the policy on both the interface and VLAN.</li> </ul>

## Configuring a Multi-Switch Network to Stop Creating Binding Entries from a Trunk Port

In a multi-switch network, SIFS-based device tracking provides the capability to distribute binding table entries between switches running the feature. Binding entries are only created on the switches where the host appears on an access port. No entry is created for a host that appears over a trunk port. This is achieved by configuring a policy with the **trusted-port** and **device-role switch** options, and attaching it to the trunk port.



### Important

Both, the **trusted-port**, and **device-role switch** options, must be configured in the policy.

Further, we recommended that you apply such a policy on a port facing a device, which also has SIFS-based device tracking enabled.

Complete the following steps:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters the global configuration mode.
<b>Step 2</b>	<b>device-tracking policy</b> <i>policy-name</i> <b>Example:</b> Device(config)# <b>device-tracking policy example_trusted_policy</b>	Enters the device-tracking policy configuration mode, for the specified policy.
<b>Step 3</b>	<b>device-role switch</b> <b>Example:</b> Device(config-device-tracking)# <b>device-role switch</b>	Specifies the role of the device attached to the port. Default is node. Enter the <b>device-role switch</b> option to stop the creation of binding entries for the port.
<b>Step 4</b>	<b>trusted-port</b> <b>Example:</b> Device(config-device-tracking)# <b>trusted-port</b>	Sets up a trusted port. Disables the guard on applicable targets. Bindings learned through a trusted port have preference over bindings learned through any other port. A trusted port is given preference in case of a collision while making an entry in the table.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-device-tracking)# <b>end</b>	Exits the device-tracking policy configuration mode and enters the global configuration mode
<b>Step 6</b>	<b>interface</b> <i>interface</i> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/25</b>	Specifies an interface and enters the interface configuration mode.
<b>Step 7</b>	<b>device-tracking attach-policy</b> <i>policy-name</i> <b>Example:</b> Device(config-if)# <b>device-tracking attach-policy example_trusted_policy</b>	Attaches a device tracking policy to the interface or the specified VLANs on the interface.

## Configuration Examples for SISF-Based Device Tracking

These examples show sample device-tracking configuration and other recommended or related configuration for certain situations.

## Example: Programmatically Enabling SISF-Based Device Tracking in Cisco IOS XE Denali 16.3.x

### Device tracking clients: IEEE 802.1X, web authentication, Cisco TrustSec, wireless, and IPSG features

The following example shows how to enable SISF-based device-tracking for IEEE 802.1X, web authentication, Cisco TrustSec, wireless, and IPSG features (enabling device-tracking is a prerequisite for these features).



**Note** The IEEE 802.1X, web authentication, Cisco TrustSec, wireless, and IPSG features are registered to listen for device-tracking notifications; the wireless feature is the one that creates and applies the device-tracking policy WL\_DEVICE\_TRACKING\_DHCP.

```
Device# configure terminal
Device(config)# ip dhcp snooping vlan 10
Device(config)# end
Device# show device-tracking policy WL_DEVICE_TRACKING_DHCP
Policy WL_DEVICE_TRACKING_DHCP configuration:
  security-level glean (*)
  device-role node
  gleaning from Neighbor Discovery
  gleaning from DHCP
  gleaning from ARP
  gleaning from DHCP4
  NOT gleaning from protocol unkn
  tracking enable

Policy WL_DEVICE_TRACKING_DHCP is applied on the following targets:
Target  Type Policy          Feature          Target range
vlan 10 VLAN WL_DEVICE_TRACKING_DHCP Device-tracking  vlan all

note:
  Binding entry Down timer: 24 hours (*)
  Binding entry Stale timer:  24 hours (*)

(*) - Policy setting that differs between releases and policy enablers.
```

## Example: Disabling IPv6 Device Tracking on a Target

By default, SISF-based device tracking supports both IPv4 and IPv6. The following configuration examples show how you can disable IPv6 device tracking if you have to:

### Disabling IPv6 device tracking when the target is attached to a custom policy:

```
Device(config)# device-tracking policy example-policy
Device(config-device-tracking)# no protocol ndp
Device(config-device-tracking)# no protocol dhcp6
Device(config-device-tracking)# end
```



**Note** In the Cisco IOS XE Denali 16.3.x release, you cannot disable IPv6 device tracking for a programmatically created policy.

## Example: Enabling IPv6 for SVI on VLAN (To Mitigate the Duplicate Address Problem)

When IPv6 is enabled in the network and a switched virtual interface (SVI) is configured on a VLAN, we recommend that you add the following to the SVI configuration. This enables the SVI to acquire a link-local address automatically; this address is used as the source IP address of the SISF probe, thus preventing the duplicate IP address issue.

```
Device(config)# interface vlan 10
Device(config-if)# ipv6 enable
Device(config-if)# end
```

## Example: Mitigating the IPv4 Duplicate Address Problem

This example show how you can tackle the Duplicate IP Address 0.0.0.0 error message problem encountered by clients that run Microsoft Windows:

Configure the **device-tracking tracking auto-source** command. This command determines the source IP and MAC address used in the Address Resolution Packet (ARP) request sent by the switch to probe a client, in order to maintain its entry in the device-tracking table. The purpose, is to avoid using 0.0.0.0 as source IP address.



**Note** Configure the **device-tracking tracking auto-source** command only when a switch virtual interface (SVI) is not configured. You do not have to configure it when a SVI is configured with an IPv4 address on the VLAN.

Command	Action (In order to select source IP and MAC address for device tracking ARP probe)	Notes
<b>device-tracking tracking auto-source</b>	<ul style="list-style-type: none"> <li>• Set source to VLAN SVI if present.</li> <li>• Look for IP and MAC binding in device-tracking table from same subnet.</li> <li>• Use 0.0.0.0</li> </ul>	We recommend that you disable device-tracking on all trunk ports to avoid MAC flapping.
<b>device-tracking tracking auto-source override</b>	<ul style="list-style-type: none"> <li>• Set source to VLAN SVI if present</li> <li>• Use 0.0.0.0</li> </ul>	Not recommended when there is no SVI.



Command	Action (In order to select source IP and MAC address for device tracking ARP probe)	Notes
<b>device-tracking tracking auto-source fallback 0.0.0.X 255.255.255.0</b>	<ul style="list-style-type: none"> <li>• Set source to VLAN SVI if present.</li> <li>• Look for IP and MAC binding in device-tracking table from same subnet.</li> <li>• Compute source IP from client IP using host bit and mask provided. Source MAC is taken from the MAC address of the switchport facing the client*.</li> </ul>	<p>We recommend that you disable device-tracking on all trunk ports to avoid MAC flapping.</p> <p>The computed IPv4 address must not be assigned to any client or network device.</p>
<b>device-tracking tracking auto-source fallback 0.0.0.X 255.255.255.0 override</b>	<ul style="list-style-type: none"> <li>• Set source to VLAN SVI if present.</li> </ul> <p>Compute source IP from client IP using host bit and mask provided*. Source MAC is taken from the MAC address of the switchport facing the client*.</p>	

\* Depending on the client IP address, an IPv4 address has to be reserved for the source IP.

A reserved source IPv4 address = (client-ip and mask) | host-ip

- Client IP = 192.0.2.25
- Source IP = (192.0.2.25 and 255.255.255.0) | (0.0.0.1) = 192.0.2.1

IP address 192.0.2.1 should not be assigned to any client or network device.

## Example: Avoiding a Short Device-Tracking Binding Reachable Time

When migrating from an older release, the following configuration may be present:

```
device-tracking binding reachable-time 10
```

Remove this by entering the **no** version of the command.

## Feature History and Information for SISF-Based Device Tracking

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Release	Modification
Cisco IOS XE Denali 16.1.1	This feature was introduced.
Cisco IOS XE Denali 16.3.7	<p>Correction in the system conversion of IPv6 snooping commands and SISF-based device-tracking commands.</p> <p>IPDT → IPv6 Snooping conversion corrections:</p> <ul style="list-style-type: none"> <li>• Until Cisco IOS XE Denali 16.3.6, the system incorrectly converts the <b>ip device tracking probe delay</b> command to <b>ipv6 neighbor tracking retry-interval</b>. Starting from Cisco IOS XE Denali 16.3.7, this is set to the default value and cannot be changed.</li> <li>• Until Cisco IOS XE Denali 16.3.6, the system incorrectly converts the <b>ip device tracking probe interval</b> command to <b>ipv6 neighbor tracking retry-interval</b>. Starting from Cisco IOS XE Denali 16.3.7, this is correctly converted to <b>ipv6 snooping tracking retry-interval</b></li> </ul> <p>IPDT → SISF conversion corrections:</p> <ul style="list-style-type: none"> <li>• Until Cisco IOS XE Denali 16.3.6 the system incorrectly converts the <b>ip device tracking probe delay</b> command to <b>device-tracking binding reachable-lifetime</b>. In the specified releases, you can still use this command, but to only configure the reachable-lifetime of an entry. Starting from Cisco IOS XE Denali 16.3.7, this is set to the default value and cannot be changed.</li> <li>• Until Cisco IOS XE Denali 16.3.6, the system incorrectly converts the <b>ip device tracking probe interval</b> command to <b>device-tracking tracking retry-interval</b>. Starting from Cisco IOS XE Denali 16.3.7, this is correctly converted to <b>device-tracking binding reachable-lifetime</b>.</li> </ul>



## CHAPTER 116

# Configuring Cisco TrustSec

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- [Finding Feature Information, on page 2198](#)
- [Cisco TrustSec Features, on page 2198](#)
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## Information about Cisco TrustSec

Cisco TrustSec provides security improvements to Cisco network devices based on the capability to strongly identify users, hosts, and network devices within a network. TrustSec provides topology-independent and scalable access controls by uniquely classifying data traffic for a particular role. TrustSec ensures data confidentiality and integrity by establishing trust among authenticated peers and encrypting links with those peers.

The key component of Cisco TrustSec is the Cisco Identity Services Engine (ISE). Cisco ISE can provision switches with TrustSec Identities and Security Group ACLs (SGACLs), though these may be configured manually on the switch.

### MTU Guidelines

CTS tagged packets greater than 1518 bytes may get dropped on the Cisco vWLC controller. This is due to a restriction on the size of incoming packets on the UCS server, which is hosting vWLC instances. The UCS server have a default MTU of 1500 thereby allowing packets of 1518 bytes only. Here, the additional 18 bytes includes 4 bytes of 802.1Q and 14 bytes of Ethernet header.

An Ethernet link configured for CTS tagging imposes a 8-byte encapsulation called Cisco metadata. As a result, the total size of the Ethernet packet is increased by 8 bytes to 1526 bytes ( $1518+8 = 1526$ ). Hence, the MTU of the receiving interface has to be increased by 8-bytes to accommodate the additional 8 bytes in the Ethernet.

While CTS interfaces on the routers and switches (for example, Cisco ASR 1000 Series Routers, Cisco 4000 Series Integrated Services Routers, Cisco Catalyst 3000 Series Switches, Cisco Catalyst 9000 Series Switches) auto-adjusts MTU to 1508 bytes to accommodate additional 8-byte. However, other devices like UCS servers requires manual update to increase the MTU to 1508. For information on how to configure jumbo MTU on UCS, see the following link:

<https://www.cisco.com/c/en/us/support/docs/servers-unified-computing/ucs-b-series-blade-servers/117601-configure-UCS-00.html>

## Finding Feature Information

To configure Cisco TrustSec on the switch, see the Cisco TrustSec Switch Configuration Guide at the following URL:

<https://www.cisco.com/c/en/us/td/docs/switches/lan/trustsec/configuration/guide/trustsec.html>

Release notes for Cisco TrustSec General Availability releases are at the following URL:

[https://www.cisco.com/c/en/us/td/docs/switches/lan/trustsec/release/notes/m\\_cts\\_crossplat.html](https://www.cisco.com/c/en/us/td/docs/switches/lan/trustsec/release/notes/m_cts_crossplat.html)

For restrictions and limitations on Catalyst 3850 and 3650, see the notes available at the following URL:

[http://www.cisco.com/c/en/us/td/docs/switches/lan/trustsec/configuration/guide/trustsec/appa\\_cat3k.html](http://www.cisco.com/c/en/us/td/docs/switches/lan/trustsec/configuration/guide/trustsec/appa_cat3k.html)

Additional information about the Cisco TrustSec solution, including overviews, datasheets, features by platform matrix, and case studies, is available at the following URL:

<https://www.cisco.com/c/en/us/solutions/enterprise-networks/trustsec/index.html>

## Cisco TrustSec Features

The table below lists the TrustSec features to be eventually implemented on TrustSec-enabled Cisco switches. Successive general availability releases of TrustSec will expand the number of switches supported and the number of TrustSec features supported per switch.

Cisco TrustSec Feature	Description
802.1AE Tagging (MACsec)	<p>Protocol for IEEE 802.1AE-based wire-rate hop-to-hop Layer 2 encryption.</p> <p>Between MACsec-capable devices, packets are encrypted on egress from the transmitting device, decrypted on ingress to the receiving device, and in the clear within the devices.</p> <p>This feature is only available between TrustSec hardware-capable devices.</p> <p><b>Note</b> This feature is not supported on Catalyst 3850 and Catalyst 3650 switches with Cisco IOS XE Denali 16.1.1</p>
Endpoint Admission Control (EAC)	<p>EAC is an authentication process for an endpoint user or a device connecting to the TrustSec domain. Usually EAC takes place at the access level switch. Successful authentication and authorization in the EAC process results in Security Group Tag assignment for the user or device. Currently EAC can be 802.1X, MAC Authentication Bypass (MAB), and Web Authentication Proxy (WebAuth).</p>

Cisco TrustSec Feature	Description
Network Device Admission Control (NDAC)	<p>NDAC is an authentication process where each network device in the TrustSec domain can verify the credentials and trustworthiness of its peer device. NDAC utilizes an authentication framework based on IEEE 802.1X port-based authentication and uses EAP-FAST as its EAP method. Successful authentication and authorization in NDAC process results in Security Association Protocol negotiation for IEEE 802.1AE encryption.</p>
Security Group Access Control List (SGACL)	<p>A Security Group Access Control List (SGACL) associates a Security Group Tag with a policy. The policy is enforced upon SGT-tagged traffic egressing the TrustSec domain.</p> <p>In Cisco IOS XE Fuji 16.8.1, IPv6 support was enabled for SGACL enforcement and logging of VRF name was enabled in SGACL logs.</p>
Cisco TrustSec SGACL High Availability	<p>Cisco TrustSec Security Group access control lists (SGACLs) support the high availability functionality on switches that support the Cisco StackWise technology. Cisco StackWise technology provides stateful redundancy and allows the switch stack to enforce and process access control entries.</p> <p>There is no Cisco TrustSec-specific configuration to enable this functionality.</p> <p>This feature is supported only on Catalyst 3850 and 3650 Series Switches from Cisco IOS XE Release Denali 16.2.1 and higher.</p>
Security Association Protocol (SAP)	<p>After NDAC authentication, the Security Association Protocol (SAP) automatically negotiates keys and the cipher suite for subsequent MACSec link encryption between TrustSec peers. SAP is defined in IEEE 802.11i.</p> <p><b>Note</b> This feature is not supported on Catalyst 3850 and Catalyst 3650 switches with Cisco IOS XE Denali 16.1.1</p>
Security Group Tag (SGT)	<p>An SGT is a 16-bit single label indicating the security classification of a source in the TrustSec domain. It is appended to an Ethernet frame or an IP packet.</p> <p>In Cisco IOS XE Fuji 16.8.1, Layer 2 Inline Tagging is supported for IPv6 multicast traffic with unicast source IPv6 addresses.</p>

Cisco TrustSec Feature	Description
SGT Exchange Protocol (SXP)	Security Group Tag Exchange Protocol (SXP). With SXP, devices that are not TrustSec-hardware-capable can receive SGT attributes for authenticated users and devices from the Cisco Identity Services Engine (ISE) or the Cisco Secure Access Control System (ACS). The devices can then forward a sourceIP-to-SGT binding to a TrustSec-hardware-capable device will tag the source traffic for SGACL enforcement.

When both ends of a link support 802.1AE MACsec, SAP negotiation occurs. An EAPOL-key exchange occurs between the supplicant and the authenticator to negotiate a cipher suite, exchange security parameters, and manage keys. Successful completion of these tasks results in the establishment of a security association (SA).

Depending on your software version and licensing and link hardware support, SAP negotiation can use one of these modes of operation:

- Galois Counter Mode (GCM)—authentication and encryption
- GCM authentication (GMAC)— GCM authentication, no encryption
- No Encapsulation—no encapsulation (clear text)
- Null—encapsulation, no authentication or encryption

## Feature Information for Cisco TrustSec

*Table 170: Feature Information for Cisco TrustSec*

Feature Name	Release	Feature Information
<ul style="list-style-type: none"> <li>• NDAC</li> <li>• SXPv1, SXPv2</li> <li>• SGT</li> <li>• SGACL Layer2 Enforcement</li> <li>• Interface to SGT and VLAN to SGT mapping.</li> <li>• Subnet to SGT mapping</li> <li>• Layer 3 Port Mapping (PM)</li> <li>• Layer 3 Identity Port Mapping (IPM)</li> <li>• Security Group Name Download</li> <li>• SXP Loop Detection</li> <li>• Policy-based CoA</li> </ul>	Cisco IOS XE 3.3SE	These features were introduced on the Catalyst 3850 and 3650 switches.



## CHAPTER 117

# Configuring Control Plane Policing

- [Restrictions for CoPP, on page 2201](#)
- [Information About Control Plane Policing, on page 2202](#)
- [How to Configure CoPP, on page 2206](#)
- [Examples for Configuring CoPP, on page 2210](#)
- [Monitoring CoPP, on page 2213](#)
- [Feature History and Information For CoPP, on page 2213](#)

## Restrictions for CoPP

Restrictions for control plane policing (CoPP) include the following:

- Only ingress CoPP is supported. The **system-cpp-policy** policy-map is available on the control plane interface, and only in the ingress direction.
- Only the **system-cpp-policy** policy-map can be installed on the control plane interface.
- The **system-cpp-policy** policy-map and the system-defined classes cannot be modified or deleted.
- Only the **police** action is allowed under the **system-cpp-policy** policy-map. The police rate for system-defined classes must be configured only in packets per second (pps); for user-defined class maps this must be configured only in bits per second (bps).
- One or more CPU queues are part of each class-map. Where multiple CPU queues belong to one class-map, changing the policer rate of a class-map affects all CPU queues that belong to that class-map. Similarly, disabling the policer in a class-map disables all queues that belong to that class-map. See [Table 171: System-Defined Values for CoPP, on page 2203](#) for information about which CPU queues belong to each class-map.
- The **show run** command does not display information about classes configured under `system-cpp policy`, when they are left at default values. Use the **show policy-map system-cpp-policy** or the **show policy-map control-plane** commands instead.

You can continue use the **show run** command to display information about custom policies.

### Related Topics

[Enabling a CPU Queue or Changing the Policer Rate, on page 2206](#)

[Disabling a CPU Queue, on page 2208](#)

[Setting the Default Policer Rates for All CPU Queues, on page 2209](#)

[User-Configurable Aspects of CoPP](#), on page 2205

# Information About Control Plane Policing

This chapter describes how control plane policing (CoPP) works on your device and how to configure it.

## CoPP Overview

The CoPP feature improves security on your device protecting the CPU from unnecessary traffic and DoS attacks. It can also protect control and management traffic from traffic drops caused by high volumes of other, lower priority traffic.

Your device is typically segmented into three planes of operation, each with its own objective:

- The data plane, to forward data packets.
- The control plane, to route data correctly.
- The management plane, to manage network elements.

You can use CoPP to protect most of the CPU-bound traffic and ensure routing stability, reachability, and packet delivery. Most importantly, you can use CoPP to protect the CPU from a DoS attack.

CoPP uses the modular QoS command-line interface (MQC) and CPU queues to achieve these objectives. Different types of control plane traffic are grouped together based on certain criteria, and assigned to a CPU queue. You can manage these CPU queues by configuring dedicated policers in hardware. For example, you can modify the policer rate for certain CPU queues (traffic-type), or you can disable the policer for a certain type of traffic.

Although the policers are configured in hardware, CoPP does not affect CPU performance or the performance of the data plane. But since it limits the number of packets going to CPU, the CPU load is controlled. This means that services waiting for packets from hardware may see a more controlled rate of incoming packets (the rate being user-configurable).

## System-Defined Aspects of CoPP

When you power-up the device for the first time, the system automatically performs the following tasks:

- Looks for policy-map **system-cpp-policy**. If not found, the system creates and installs it on the control-plane.
- Creates eighteen class-maps under **system-cpp-policy**.

The next time you power-up the device, the system detects the policy and class maps that have already been created.

- Enables all CPU queues by default, with their respective default rate. The default rates are indicated in the table System-Defined Values for CoPP.

The following table lists the class-maps that the system creates when you load the device. It lists the policer that corresponds to each class-map and one or more CPU queues that are grouped under each class-map. There is a one-to-one mapping of class-maps to policers; and one or more CPU queues map to a class-map.



Table 171: System-Defined Values for CoPP

Class Maps Names	Policer Index (Policer No.)	CPU queues (Queue No.)	Default Policer Rate (pps)
system-cpp- police-data	WK_CPP_POLICE_DATA(0)	WK_CPU_Q_ICMP_GEN(3)	600
		WK_CPU_Q_BROADCAST(12)	600
		WK_CPU_Q_ICMP_REDIRECT (6)	600
system-cpp-police-l2- control	WK_CPP_POLICE_L2_CONTROL(1)	WK_CPU_Q_L2_CONTROL(1)	2000
system-cpp-police-routing-control	WK_CPP_POLICE_ROUTING_CONTROL(0)	WK_CPU_Q_ROUTING_CONTROL(4)	5400
		WK_CPU_Q_LOW_LATENCY (27)	5400
system-cpp-police-punt-webauth	WK_CPP_POLICE_PUNT_WEBAUTH(7)	WK_CPU_Q_PUNT_WEBAUTH(22)	1000
system-cpp-police-topology-control	WK_CPP_POLICE_TOPOLOGY_CONTROL(8)	WK_CPU_Q_TOPOLOGY_CONTROL(15)	13000
system-cpp-police- multicast	WK_CPP_POLICE_MULTICAST(9)	WK_CPU_Q_TRANSIT_TRAFFIC(18)	500
		WK_CPU_Q_MCAST_DATA(30)	500
system-cpp-police-sys- data	WK_CPP_POLICE_SYS_DATA (10)	WK_CPU_Q_OPENFLOW (13)	100
		WK_CPU_Q_CRYPTO_CONTROL(23)	100
		WK_CPU_Q_EXCEPTION(24)	100
		WK_CPU_Q_EGR_EXCEPTION(28)	100
		WK_CPU_Q_NF_SAMPLED_DATA(26)	100
		WK_CPU_Q_GOLD_PKT(31)	100
WK_CPU_Q_RPF_FAILED(19)	100		
system-cpp-police-dot1x-auth	WK_CPP_POLICE_DOT1X(11)	WK_CPU_Q_DOT1X_AUTH(0)	1000
system-cpp-police-protocol-snooping	WK_CPP_POLICE_PROTO_SNOOPING	WK_CPU_Q_PROTO_SNOOPING(16)	2000
system-cpp-police-dhcp-snooping	WK_CPP_DHCP_SNOOPING	WK_CPU_Q_DHCP_SNOOPING(17)	500
system-cpp-police-sw-forward	WK_CPP_POLICE_SW_FWD (13)	WK_CPU_Q_SW_FORWARDING_Q(14)	1000
		WK_CPU_Q_LOGGING(21)	1000
		WK_CPU_Q_L2_LVX_DATA_PACK (11)	1000
system-cpp-police-forus	WK_CPP_POLICE_FORUS(14)	WK_CPU_Q_FORUS_ADDR_RESOLUTION(5)	4000
		WK_CPU_Q_FORUS_TRAFFIC(2)	4000

Class Maps Names	Policer Index (Policer No.)	CPU queues (Queue No.)	Default Policer Rate (pps)
system-cpp-police-multicast-end-station	WK_CPP_POLICY_MCAST	WK_CPU_Q_MCAST_END_STATION_SERVICE(20)	2000
system-cpp-default	WK_CPP_POLICY_DEFAULT	WK_CPU_Q_INTER_FED_TRAFFIC WK_CPU_Q_EWLC_CONTROL(9) WK_CPU_Q_EWLC_DATA(10)	2000 2000 2000
system-cpp-police-stackwise-vit-control	WK_CPP_POLICY_STACKWISE_VIT_CTRL	WK_CPU_Q_STACKWISE_VIRTUAL_CTRL(29)	8000
system-cpp-police-l2lvx-control	WK_CPP_L2_LVX_CONT_PACK	WK_CPU_Q_L2_LVX_CONT_PACK(8)	1000
system-cpp-police-high-rate-app	WK_CPP_HIGH_RATE_APP	WK_CPU_Q_HIGH_RATE_APP	13000
system-cpp-police-system-critical	WK_CPP_SYSTEM_CRITICAL	WK_CPU_Q_SYSTEM_CRITICAL	1000

When you upgrade or downgrade the software version on your device, note the following:

- When upgrading from one software release to another:

The upgrade could be from Cisco IOS XE Release 3.x.xE to a Cisco IOS XE 16.x.x release, or from one Cisco IOS XE 16.x.x release to another Cisco IOS XE 16.x.x release:

- If the device did not have a `system-cpp-policy` policy map before upgrade, then on upgrade, a default policy is created.
- If the device had a `system-cpp-policy` policy map before upgrade, then on upgrade, the policy is not re-generated. Enter the `cpp system-default` command in global configuration mode to get the default policy working.




---

**Note** We recommend that you to enter the `cpp system-default` command after any major upgrade to get the latest, default policer rates.

---

- When downgrading from one software release to another:

The downgrade could be from a Cisco IOS XE 16.x.x release to a Cisco IOS XE Release 3.x.xE, or from one Cisco IOS XE 16.x.x release to another Cisco IOS XE 16.x.x release:

- The `system-cpp-policy` policy map is retained on the device, but not installed on the control plane. You can delete the policy.

- If you downgrade to an earlier release and then upgrade to a later release:

For example, if you downgrade from Cisco IOS XE 16.x.x release to Cisco IOS XE Release 3.x.xE and then upgrading to a Cisco IOS XE 16.x.x release:

- If you delete the policy after downgrading to Cisco IOS XE Release 3.x.xE and then upgrade to a Cisco IOS XE 16.x.x release, the policy is generated with defaults.

- If you do not delete the policy after downgrading to Cisco IOS XE Release 3.x.xE, then on upgrade to a Cisco IOS XE 16.x.x release, the policy is not regenerated.

Enter the **cpp system-default** command in global configuration mode to get the default policy working.

## User-Configurable Aspects of CoPP

You can perform these tasks to manage control plane traffic:



---

**Note** All `system-cpp-policy` configurations must be saved so they are retained after reboot.

---

### Enable or Disable a Policer for CPU Queues

Enable a policer for a CPU queue, by configuring a policer action (in packets per second) under the corresponding class-map, within the `system-cpp-policy` policy-map.

Disable a policer for CPU queue, by removing the policer action under the corresponding class-map, within the `system-cpp-policy` policy-map.



---

**Note** If a default policer is already present, carefully consider and control its removal; otherwise the system may see a CPU hog or other anomalies, such as control packet drops.

---

### Change the Policer Rate

You can do this by configuring a policer rate action (in packets per second), under the corresponding class-map, within the `system-cpp-policy` policy-map.

### Set Policer Rates to Default

Set the policer for CPU queues to their default values, by entering the **cpp system-default** command in global configuration mode.

### Create User-Defined Class Maps

If a given traffic class does not have a designated class map, and you want to protect this traffic, you can create specific class maps (with filters) for such traffic packets and add these user-defined class maps to `system-cpp-policy`.

While `system-cpp-policy` is applied in the ingress direction, the forwarding engine driver (FED) changes policers on user-defined class maps to the egress. The filters and the policers in all user-defined classes must therefore be applied as egress classifications and actions, respectively. The policy map itself is unaffected by this change in the direction.

When you add a user-defined class map to `system-cpp-policy`, the system automatically installs it on all 32 CPU queues (in addition to the control plane), resulting in 33 instances of the policy. You can see this by entering the **show platform software fed switch** `{switch_number | active | standby}` qos policy target status command in privileged EXEC mode.

The police rate on these class maps is controlled by the Active Queue Management (AQM) policer. AQM provides buffering control of traffic flows prior to queuing a packet into the transmit queue of a port, ensuring that certain flows do not hog the switch packet memory. If the AQM policer feature is enabled, any user-defined police rates exceeding the AQM policer limits are disregarded.

User defined class maps have normal QoS or ACL classification filters.

#### Related Topics

[Enabling a CPU Queue or Changing the Policer Rate](#), on page 2206

[Disabling a CPU Queue](#), on page 2208

[Setting the Default Policer Rates for All CPU Queues](#), on page 2209

[Restrictions for CoPP](#), on page 2201

[Example: Enabling a CPU Queue or Changing the Policer Rate of a CPU Queue](#), on page 2210

[Example: Disabling a CPU Queue](#)

[Example: Setting the Default Policer Rates for All CPU Queues](#), on page 2211

## How to Configure CoPP

### Enabling a CPU Queue or Changing the Policer Rate

The procedure to enable a CPU queue and change the policer rate of a CPU queue is the same. Follow these steps:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>policy-map</b> <i>policy-map-name</i> <b>Example:</b> Device (config)# <b>policy-map</b> <b>system-cpp-policy</b> Device (config-pmap) #	Enters the policy map configuration mode.
<b>Step 4</b>	<b>class</b> <i>class-name</i> <b>Example:</b>	Enters the class action configuration mode. Enter the name of the class that corresponds

	Command or Action	Purpose
	<pre>Device(config-pmap)# class system-cpp-police-protocol-snooping Device(config-pmap-c)#</pre>	to the CPU queue you want to enable. See table <i>System-Defined Values for CoPP</i> .
<b>Step 5</b>	<p><b>police rate rate pps</b></p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# police rate 100 pps Device(config-pmap-c-police)#</pre>	<p>Specifies an upper limit on the number of incoming packets processed per second, for the specified traffic class.</p> <p><b>Note</b> The rate you specify is applied to all CPU queues that belong to the class-map you have specified.</p>
<b>Step 6</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-pmap-c-police)# exit Device(config-pmap-c)# exit Device(config-pmap)# exit Device(config)#</pre>	Returns to the global configuration mode.
<b>Step 7</b>	<p><b>control-plane</b></p> <p><b>Example:</b></p> <pre>Device(config)# control-plane Device(config-cp)#</pre>	Enters the control plane (config-cp) configuration mode
<b>Step 8</b>	<p><b>service-policy input policy-name</b></p> <p><b>Example:</b></p> <pre>Device(config)# control-plane Device(config-cp)#service-policy input system-cpp-policy Device(config-cp)#</pre>	Installs system-cpp-policy in FED. This command is required for you to see the FED policy. Not configuring this command will lead to an error.
<b>Step 9</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-cp)# end</pre>	Returns to the privileged EXEC mode.
<b>Step 10</b>	<p><b>show policy-map control-plane</b></p> <p><b>Example:</b></p> <pre>Device# show policy-map control-plane</pre>	Displays all the classes configured under system-cpp policy, the rates configured for the various traffic types, and statistics

### Related Topics

[User-Configurable Aspects of CoPP](#), on page 2205

[Restrictions for CoPP](#), on page 2201

[Example: Enabling a CPU Queue or Changing the Policer Rate of a CPU Queue](#), on page 2210

[Example: Disabling a CPU Queue](#)

[Example: Setting the Default Policer Rates for All CPU Queues](#), on page 2211

## Disabling a CPU Queue

Follow these steps to disable a CPU queue:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>policy-map <i>policy-map-name</i></b> <b>Example:</b> Device(config)# <b>policy-map system-cpp-policy</b> Device(config-pmap)#	Enters the policy map configuration mode.
<b>Step 4</b>	<b>class <i>class-name</i></b> <b>Example:</b> Device(config-pmap)# <b>class system-cpp-police-protocol-snooping</b> Device(config-pmap-c)#	Enters the class action configuration mode. Enter the name of the class that corresponds to the CPU queue you want to disable. See the table, <i>System-Defined Values for CoPP</i> .
<b>Step 5</b>	<b>no police rate <i>rate</i> pps</b> <b>Example:</b> Device(config-pmap-c)# <b>no police rate 100 pps</b>	Disables incoming packet processing for the specified traffic class. <p><b>Note</b> This disables all CPU queues that belong to the class-map you have specified.</p>
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config-pmap-c)# <b>end</b>	Returns to the privileged EXEC mode.
<b>Step 7</b>	<b>show policy-map control-plane</b> <b>Example:</b> Device# <b>show policy-map control-plane</b>	Displays all the classes configured under <code>system-cpp policy</code> and the rates configured for the various traffic types and statistics.

**Related Topics**

[User-Configurable Aspects of CoPP](#), on page 2205

[Restrictions for CoPP](#), on page 2201

[Example: Enabling a CPU Queue or Changing the Policer Rate of a CPU Queue](#), on page 2210

[Example: Disabling a CPU Queue](#)

[Example: Setting the Default Policer Rates for All CPU Queues](#), on page 2211

## Setting the Default Policer Rates for All CPU Queues

Follow these steps to set the policer rates for all CPU queues to their default rates:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>cpp system-default</b> <b>Example:</b> Device(config)# <b>cpp system-default</b> Defaulting CPP : Policer rate for all classes will be set to their defaults	Sets the policer rates for all the classes to the default rate.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to the privileged EXEC mode.
<b>Step 5</b>	<b>show platform hardware fed switch {switch-number   active   standby} qos que stats internal cpu policer</b> <b>Example:</b> Device# <b>show platform hardware fed switch 1 qos que stat internal cpu policer</b>	Displays the rates configured for the various traffic types.

**Related Topics**

[User-Configurable Aspects of CoPP](#), on page 2205

[Restrictions for CoPP](#), on page 2201

[Example: Enabling a CPU Queue or Changing the Policer Rate of a CPU Queue](#), on page 2210

[Example: Disabling a CPU Queue](#)

[Example: Setting the Default Policer Rates for All CPU Queues](#), on page 2211

# Examples for Configuring CoPP

## Example: Enabling a CPU Queue or Changing the Policer Rate of a CPU Queue

This example shows how to enable a CPU queue or to change the policer rate of a CPU queue. Here the **class system-cpp-police-protocol-snooping** CPU queue is enabled with the policer rate of **2000 pps**.

```
Device> enable
Device# configure terminal
Device(config)# policy-map system-cpp-policy
Device(config-pmap)# class system-cpp-police-protocol-snooping
Device(config-pmap-c)# police rate 2000 pps
Device(config-pmap-c-police)# end
```

```
Device# show policy-map control-plane
Control Plane
```

```
Service-policy input: system-cpp-policy
```

```
<output truncated>
```

```
Class-map: system-cpp-police-dot1x-auth (match-any)
  0 packets, 0 bytes
  5 minute offered rate 0000 bps, drop rate 0000 bps
  Match: none
  police:
    rate 1000 pps, burst 244 packets
    conformed 0 bytes; actions:
      transmit
    exceeded 0 bytes; actions:
      drop
```

```
Class-map: system-cpp-police-protocol-snooping (match-any)
  0 packets, 0 bytes
  5 minute offered rate 0000 bps, drop rate 0000 bps
  Match: none
  police:
    rate 2000 pps, burst 488 packets
    conformed 0 bytes; actions:
      transmit
    exceeded 0 bytes; actions:
      drop
```

```
<output truncated>
```

```
Class-map: class-default (match-any)
```



```

0 packets, 0 bytes
5 minute offered rate 0000 bps, drop rate 0000 bps
Match: any

```

### Related Topics

[Enabling a CPU Queue or Changing the Policer Rate](#), on page 2206

[Disabling a CPU Queue](#), on page 2208

[Setting the Default Policer Rates for All CPU Queues](#), on page 2209

[User-Configurable Aspects of CoPP](#), on page 2205

## Example: Setting the Default Policer Rates for All CPU Queues

This example shows how to set the policer rates for all CPU queues to their default and then verify the setting.

```

Device> enable
Device# configure terminal
Device(config)# cpp system-default
Defaulting CPP : Policer rate for all classes will be set to their defaults
Device(config)# end

```

```

Device# show platform hardware fed switch 1 qos queue stats internal cpu policer
CPU Queue Statistics
=====

```

QId	PlcIdx	Queue Name	Enabled	(default) Rate	(set) Rate	Queue Drop (Bytes)	Queue Drop (Frames)
0	11	DOT1X Auth	Yes	1000	1000	0	0
1	1	L2 Control	Yes	2000	2000	0	0
2	14	Forus traffic	Yes	4000	4000	0	0
3	0	ICMP GEN	Yes	600	600	0	0
4	2	Routing Control	Yes	5400	5400	0	0
5	14	Forus Address resolution	Yes	4000	4000	0	0
6	0	ICMP Redirect	Yes	600	600	0	0
7	16	Inter FED Traffic	Yes	2000	2000	0	0
8	4	L2 LVX Cont Pack	Yes	1000	1000	0	0
9	16	EWLC Control	Yes	2000	2000	0	0
10	16	EWLC Data	Yes	2000	2000	0	0
11	13	L2 LVX Data Pack	Yes	1000	1000	0	0
12	0	BROADCAST	Yes	600	600	0	0
13	10	Openflow	Yes	100	100	0	0
14	13	Sw forwarding	Yes	1000	1000	0	0
15	8	Topology Control	Yes	13000	13000	0	0

## Example: Setting the Default Policer Rates for All CPU Queues

16	12	Proto Snooping	Yes	2000	2000	0	0
17	6	DHCP Snooping	Yes	500	500	0	0
18	9	Transit Traffic	Yes	500	500	0	0
19	10	RPF Failed	Yes	100	100	0	0
20	15	MCAST END STATION	Yes	2000	2000	0	0
21	13	LOGGING	Yes	1000	1000	0	0
22	7	Punt Webauth	Yes	1000	1000	0	0
23	18	High Rate App	Yes	13000	13000	0	0
24	10	Exception	Yes	100	100	0	0
25	3	System Critical	Yes	1000	1000	0	0
26	10	NFL SAMPLED DATA	Yes	100	200	0	0
27	2	Low Latency	Yes	5400	5400	0	0
28	10	EGR Exception	Yes	100	100	0	0
29	5	Stackwise Virtual OOB	Yes	8000	8000	0	0
30	9	MCAST Data	Yes	500	500	0	0
31	10	Gold Pkt	Yes	100	100	0	0

\* NOTE: CPU queue policer rates are configured to the closest hardware supported value

## CPU Queue Policer Statistics

```

=====
Policer      Policer Accept  Policer Accept  Policer Drop  Policer Drop
Index        Bytes          Frames          Bytes          Frames
-----
0            0              0              0              0
1            0              0              0              0
2            0              0              0              0
3            0              0              0              0
4            0              0              0              0
5            0              0              0              0
6            0              0              0              0
7            0              0              0              0
8            0              0              0              0
9            0              0              0              0
10           0              0              0              0
11           0              0              0              0
12           0              0              0              0
13           0              0              0              0
14           0              0              0              0
15           0              0              0              0
16           0              0              0              0
17           0              0              0              0
18           0              0              0              0
=====

```

## CPP Classes to queue map

```

=====
PlcIdx CPP Class                               : Queues
=====

```

```

-----
0      system-cpp-police-data          : ICMP GEN/BROADCAST/ICMP Redirect/
10     system-cpp-police-sys-data      : Openflow/Exception/EGR Exception/NFL
SAMPLED DATA/Gold Pkt/RPF Failed/
13     system-cpp-police-sw-forward    : Sw forwarding/LOGGING/L2 LVX Data Pack/
9      system-cpp-police-multicast     : Transit Traffic/MCAST Data/
15     system-cpp-police-multicast-end-station : MCAST END STATION /
7      system-cpp-police-punt-webauth  : Punt Webauth/
1      system-cpp-police-l2-control    : L2 Control/
2      system-cpp-police-routing-control : Routing Control/Low Latency/
3      system-cpp-police-system-critical : System Critical/
4      system-cpp-police-l2lvx-control  : L2 LVX Cont Pack/
8      system-cpp-police-topology-control : Topology Control/
11     system-cpp-police-dot1x-auth    : DOT1X Auth/
12     system-cpp-police-protocol-snooping : Proto Snooping/
6      system-cpp-police-dhcp-snooping  : DHCP Snooping/
14     system-cpp-police-forus         : Forus Address resolution/Forus traffic/
5      system-cpp-police-stackwise-virt-control : Stackwise Virtual OOB/
16     system-cpp-default              : Inter FED Traffic/EWLC Control/EWLC Data/
18     system-cpp-police-high-rate-app  : High Rate App/

```

### Related Topics

[Enabling a CPU Queue or Changing the Policer Rate](#), on page 2206

[Disabling a CPU Queue](#), on page 2208

[Setting the Default Policer Rates for All CPU Queues](#), on page 2209

[User-Configurable Aspects of CoPP](#), on page 2205

## Monitoring CoPP

Use these commands to display policer settings, such as, traffic types and policer rates (user-configured and default rates) for CPU queues:

Command	Purpose
<b>show policy-map control-plane</b>	Displays the rates configured for the various traffic types
<b>show policy-map system-cpp-policy</b>	Displays all the classes configured under system-cpp policy, and policer rates
<b>show platform hardware fed switch {switch-number   active   standby} qos que stats internal cpu policer</b>	Displays the rates configured for the various traffic types
<b>show platform software fed {switch-number   active   standby} qos policy target status</b>	Displays information about policy status and the target port type.

## Feature History and Information For CoPP

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Feature	Release	Feature Information
Control Plane Policing (CoPP) or CPP	Cisco IOS XE 3.2SE	This feature was introduced.
CLI configuration for CoPP	Cisco IOS XE Denali 16.1.2	This feature was made user-configurable. CLI configuration options to enable and disable CPU queues, to change the policer rate, and to set policer rates to default.
User-defined class maps	Cisco IOS XE Everest 16.5.1a	Starting with this release, you can create class maps (with filters) and add these user-defined class maps to system-cpp-policy.
Changes in system-defined values for CoPP	Cisco IOS XE Everest 16.6.1	<p>These new system-defined classes were introduced:</p> <ul style="list-style-type: none"> <li>• system-cpp-police-stackwise-virt-control</li> <li>• system-cpp-police-l2lvx-control</li> </ul> <p>These new CPU queues were added to the existing system-cpp-default class:</p> <ul style="list-style-type: none"> <li>• WK_CPU_Q_UNUSED (7)</li> <li>• WK_CPU_Q_EWLC_CONTROL(9)</li> <li>• WK_CPU_Q_EWLC_DATA(10)</li> </ul> <p>This new CPU queues was added to the existing system-cpp-police-sw-forward: WK_CPU_Q_L2_LVX_DATA_PACK (11)</p> <p>This CPU queue is no longer available: WK_CPU_Q_SGT_CACHE_FULL(27)</p>

Feature	Release	Feature Information
Changes in system-defined values for CoPP	Cisco IOS XE Fuji 16.8.1a	<p>This new system-defined class was introduced: system-cpp-police-dhcp-snooping</p> <p>This new CPU queue was added to the existing system-cpp-default class: WK_CPU_Q_INTER_FED_TRAFFIC</p> <p>These CPU queues are no longer available:</p> <ul style="list-style-type: none"> <li>• WK_CPU_Q_SHOW_FORWARD</li> <li>• WK_CPU_Q_UNUSED</li> </ul> <p>The default policer rate (pps) for some CPU queues has changed:</p> <ul style="list-style-type: none"> <li>• The default rate for WK_CPU_Q_EXCEPTION(24) was changed to 100</li> <li>• The default rate for all the CPU queues under system-cpp-default was increased to 2000.</li> <li>• The default rate for all the CPU queues under system-cpp-police-forus was increased to 4000.</li> </ul>
Changes in system-defined values for CoPP	Cisco IOS XE Fuji 16.9.1	<p>Starting with this release, eighteen system-defined classes are created under <code>system-cpp-policy</code>.</p> <p>These new system-defined classes were introduced:</p> <ul style="list-style-type: none"> <li>• system-cpp-police-high-rate-app</li> <li>• system-cpp-police-system-critical</li> </ul> <p>This was added to class system-cpp-police-sys- data: CPU queue WK_CPU_Q_OPENFLOW (13).</p> <p>This CPU queue is no longer available: WK_CPU_Q_LEARNING_CACHE_OVFL(13).</p> <p>This system-defined class is no longer available: system-cpp-police-control-low-priority</p>





## CHAPTER 118

# Configuring Wireless Guest Access

- [Finding Feature Information, on page 2217](#)
- [Prerequisites for Guest Access, on page 2217](#)
- [Restrictions for Guest Access, on page 2218](#)
- [Information about Wireless Guest Access, on page 2218](#)
- [Fast Secure Roaming, on page 2218](#)
- [How to Configure Guest Access, on page 2219](#)
- [Configuration Examples for Guest Access, on page 2232](#)
- [Additional References for Guest Access, on page 2238](#)
- [Feature History and Information for Guest Access, on page 2239](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Guest Access

- All mobility peers should be configured for hierarchical mobility architecture.
- For Guest Controller Mobility Anchor configuration on WLAN is must on Mobility Agent and Guest Controller.
- Guest Access can be a 3 box solution or 2 box solution. The mobility tunnel link status should be up between:
  - Mobility Agent, Mobility Controller and Guest Controller.or
  - Mobility Agent/Mobility Controller and Guest Controller

# Restrictions for Guest Access

## Information about Wireless Guest Access

Ideally, the implementation of a wireless guest network uses as much of an enterprise's existing wireless and wired infrastructure as possible to avoid the cost and complexity of building a physical overlay network. Assuming this is the case, the following additional elements and functions are needed:

- A dedicated guest WLAN/SSID—Implemented throughout the campus wireless network wherever guest access is required. A guest WLAN is identified by a WLAN with mobility anchor (Guest Controller) configured.
- Guest traffic segregation—Requires implementing Layer 2 or Layer 3 techniques across the campus network to restrict where guests are allowed to go.
- Access control—Involves using imbedded access control functionality within the campus network or implementing an external platform to control guest access to the Internet from the enterprise network.
- Guest user credential management—A process by which a sponsor or lobby administrator can create temporary credentials in behalf of a guest. This function might be resident within an access control platform or it might be a component of AAA or some other management system.

## Fast Secure Roaming

Fast secure roaming can be achieved by caching the Pairwise Master Key (PMK) information for Cisco Centralized Key Management (CCKM), and 802.11i clients. Cisco Centralized Key Management (CCKM) helps to improve roaming. Only the client can initiate the roaming process, which depends on factors such as:

- Overlap between APs
- Distance between APs
- Channel, signal strength, and load on the AP
- Data rates and output power

Whenever a fast-roaming client 802.11i, [CCKM]) roams to a new device, after fast-roaming the clients go through mobility "handoff" procedure. And new AAA attributes learned through mobility "handoff" procedure get re-applied.

Full L2 authentication must be avoided during roaming if the client uses the 802.11i WPA2, CCKM, to achieve the full requirements of fast secure roaming. The PMK cache (802.11i, CCKM) is used to authenticate and derive the keys for roaming clients to avoid full L2 authentication. This requires all Mobility Anchors (MA) and Mobility Controllers (MC) in the mobility group to have the same PMK cache values.

The session timeout defines when a PMK cache will expire. A PMK cache can also be deleted when a client fails to re-authenticate or when it is manually deleted them from the CLI. The deletion on the original controller or switch shall be propagated to other controllers or switches in the same mobility group.



# How to Configure Guest Access

## Creating a Lobby Administrator Account

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device # <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>user-name user-name</b> <b>Example:</b> Device (config)# <b>user-name lobby</b>	Creates a user account.
<b>Step 3</b>	<b>type lobby-admin</b> <b>Example:</b> Device (config-user-name)# <b>type lobby-admin</b>	Specifies the account type as lobby admin.
<b>Step 4</b>	<b>password 0 password</b> <b>Example:</b> Device(config-user-name)# <b>password 0 lobby</b>	Creates a password for the lobby administrator account.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device (config-user-name)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config   section user-name</b> (or) <b>show running-config   section configured lobby admin username</b> <b>Example:</b> Device # <b>show running-config   section lobby</b>	Displays the configuration details.

## Example

## Configuring Guest User Accounts

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device # <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>user-name</b> <i>user-name</i> <b>Example:</b> Device (config)# <b>user-name</b> guest	Creates a username for the lobby ambassador account.
<b>Step 3</b>	<b>password</b> <i>unencrypted/hidden-password</i> <i>password</i> <b>Example:</b> Device (config-user-name)# <b>password</b> 0 guest	Specifies the password for the user.
<b>Step 4</b>	<b>type network-user description</b> <i>description</i> <b>guest-user lifetime year</b> <i>0-1</i> <b>month</b> <i>0-11</i> <b>day</b> <i>0-30</i> <b>hour</b> <i>0-23</i> <b>minute</b> <i>0-59</i> <b>second</b> <i>0-59</i> <b>Example:</b> Device (config-user-name)# <b>type</b> <b>network-user description</b> guest <b>guest-user</b> <b>lifetime</b> <b>year</b> 1 <b>month</b> 10 <b>day</b> 3 <b>hour</b> 1 <b>minute</b> 5 <b>second</b> 30	Specifies the type of user.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device (config-user-name)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show aaa local netuser all</b> <b>Example:</b> Device # <b>show aaa local netuser all</b>	Displays the configuration details. After the lifetime, the user-name with guest type will be deleted and the client associated with the guest user-name will be de-authenticated.
<b>Step 7</b>	<b>show running-config   section</b> <i>user-name</i> <b>Example:</b> Device # <b>show running-config   section</b> guest	Displays the configuration details.

## Example

## Configuring Mobility Agent (MA)

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device # <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wireless mobility controller ip</b> <i>mc-ipaddress</i> <b>public-ip</b> <i>mc-publicipaddress</i> <b>Example:</b> Device (config) # <b>wireless mobility controller ip</b> <i>27.0.0.1</i> <b>public-ip</b> <i>27.0.0.1</i>	Configures the Mobility Controller to which the MA will be associated.
<b>Step 3</b>	<b>wlan</b> <i>wlan-name</i> <i>wlan-id</i> <i>ssid</i> <b>Example:</b> Device (config) # <b>wlan</b> <i>mywlan</i> <i>34</i> <i>mywlan-ssid</i>	<ul style="list-style-type: none"> <li>• For <i>wlan-name</i> enter, enter the profile name. The range is 1- 32 characters.</li> <li>• For <i>wlan-id</i>, enter the WLAN ID. The range is 1-512.</li> <li>• For <i>ssid</i>, enter the Service Set Identifier (SSID) for this WLAN. If the SSID is not specified, the WLAN profile name is set as the SSID.</li> </ul>
<b>Step 4</b>	<b>client vlan id</b> <i>vlan-group name/vlan-id</i> <b>Example:</b> Device (config-wlan) # <b>client vlan</b> <i>VLAN0136</i>	Configures the VLAN id or group of the WLAN.
<b>Step 5</b>	<b>no security wpa</b> <b>Example:</b> Device (config-wlan) # <b>no security wpa</b>	The security configuration must be the same for the WLAN created on the GC. This example is for open authentication. For other security types such as open and webauth, appropriate command should be provided.
<b>Step 6</b>	<b>mobility anchor</b> <i>ipaddress</i> <b>Example:</b> Device (config-wlan) # <b>mobility anchor</b> <i>9.3.32.2</i>	Configures the Guest Controller as mobility anchor.
<b>Step 7</b>	<b>aaa-override</b> <b>Example:</b>	(Optional) Enables AAA override. AAA override is required for non open

	Command or Action	Purpose
	Device (config-wlan) # <b>aaa-override</b>	authentication in case AAA attributes are to be prioritized. It is required only in case guest user need to be deauthenticated after lifetime or have to give aaa-override attribute to the user.
<b>Step 8</b>	<b>no shutdown</b> <b>Example:</b> Device (config-wlan) # <b>no shutdown</b>	Enables the WLAN.
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 10</b>	<b>show wireless mobility summary</b> <b>Example:</b> Device # <b>show wireless mobility summary</b>	Verifies the mobility controller IP address and mobility tunnel status.
<b>Step 11</b>	<b>show wlan name wlan-name/id</b> <b>Example:</b> Device # <b>show wlan name mywlan</b>	Displays the configuration of mobility anchor.

### Example

## Configuring Mobility Controller

Mobility Controller mode should be enabled using the **wireless mobility controller** command.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device # <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wireless mobility group member ip ip-address public-ip ip-address group group-name</b> <b>Example:</b> Device (config) # <b>wireless mobility group member ip 27.0.0.1 public-ip 23.0.0.1 group test</b>	Adds all peers within the MC group. The <i>ip-address</i> should be the guest controller's IP address.
<b>Step 3</b>	<b>wireless mobility controller peer-group peer-group-name</b>	Creates the switch peer group.

	Command or Action	Purpose
	<b>Example:</b> Device (config) # <b>wireless mobility controller peer-group pg</b>	
<b>Step 4</b>	<b>wireless mobility controller peer-group peer-group-name member ip ipaddress public-ip ipaddress</b>  <b>Example:</b> Device (config) # <b>wireless mobility controller peer-group pg member ip 9.7.136.10 public-ip 9.7.136.10</b>	Adds the MA to the switch peer group.
<b>Step 5</b>	<b>end</b>  <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show wireless mobility summary</b>  <b>Example:</b> Device # <b>show wireless mobility summary</b>	Displays the configuration details.

### Example

## Obtaining a Web Authentication Certificate

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device # <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>crypto pki import trustpoint name pkcs12 tftp: passphrase</b>  <b>Example:</b> Device (config)# <b>crypto pki import cert pkcs12 tftp://9.1.0.100/ldapserver-cert.p12 cisco</b>	Imports certificate.
<b>Step 3</b>	<b>end</b>  <b>Example:</b> Device (config)# <b>end</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 4</b>	<b>show crypto pki trustpoints cert</b>  <b>Example:</b> Device # <b>show crypto pki trustpoints cert</b>	Displays the configuration details.

**Example**

## Displaying a Web Authentication Certificate

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>show crypto ca certificate verb</b>  <b>Example:</b> Device # <b>show crypto ca certificate verb</b>	Displays the current web authentication certificate details.

**Example**

## Choosing the Default Web Authentication Login Page

AAA override flag should be enabled on the WLAN for web authentication using local or remote AAA server.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device # <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>parameter-map type webauth</b> <i>parameter-map name</i>  <b>Example:</b> Device (config) # <b>parameter-map type</b> <b>webauth test</b>	Configures the web-auth parameter-map.
<b>Step 3</b>	<b>wlan wlan-name</b>  <b>Example:</b> Device (config) # <b>wlan wlan10</b>	For the wlan-name, enter the profile name. The range is 1- 32 characters.
<b>Step 4</b>	<b>shutdown</b>	Disables WLAN.

	Command or Action	Purpose
	<b>Example:</b> Device (config) # <b>shutdown</b>	
<b>Step 5</b>	<b>security web-auth</b> <b>Example:</b> Controller (config-wlan) # <b>security web-auth</b>	Enables web-auth on WLAN.
<b>Step 6</b>	<b>security web-auth authentication-list</b> <i>authentication list name</i> <b>Example:</b> Controller (config-wlan) # <b>security web-auth authentication-list test</b>	Allows you to map the authentication list name with the web-auth WLAN.
<b>Step 7</b>	<b>security web-auth parameter-map</b> <i>parameter-map name</i> <b>Example:</b> Device (config) # <b>security web-auth parameter-map test</b>	Allows you to map the parameter-map name with the web-auth WLAN.
<b>Step 8</b>	<b>no shutdown</b> <b>Example:</b> Device (config) # <b>no shutdown</b>	Enables the WLAN.
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 10</b>	<b>show running-config   section wlan-name</b> <b>Example:</b> Device# <b>show running-config   section mywlan</b>	Displays the configuration details.
<b>Step 11</b>	<b>show running-config   section parameter-map type webauth</b> <i>parameter-map</i> <b>Example:</b> Device# <b>show running-config   section parameter-map type webauth test</b>	Displays the configuration details.

## Example

## Choosing a Customized Web Authentication Login Page from an External Web Server

AAA override flag should be enabled on the WLAN for web authentication using local or remote AAA server.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device # <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>parameter-map type webauth global</b>  <b>Example:</b> Device (config) # <code>parameter-map type webauth global</code>	Configures a global webauth type parameter.
<b>Step 3</b>	<b>virtual-ip {ipv4   ipv6} ip-address</b>  <b>Example:</b> Device (config-params-parameter-map) # <code>virtual-ip ipv4 192.0.2.1</code>	Configures the virtual IP address.
<b>Step 4</b>	<b>parameter-map type webauth parameter-map name</b>  <b>Example:</b> Device (config-params-parameter-map) # <code>parameter-map type webauth test</code>	Configures the webauth type parameter.
<b>Step 5</b>	<b>type {authbypass   consent   webauth   webconsent}</b>  <b>Example:</b> Device (config-params-parameter-map) # <code>type webauth</code>	Configures webauth subtypes such as consent, passthru, webauth, or webconsent.
<b>Step 6</b>	<b>redirect [for-login on-success on-failure] URL</b>  <b>Example:</b> Device (config-params-parameter-map) # <code>redirect for-login http://9.1.0.100/login.html</code>	Configures the redirect URL for the log in page, success page, and failure page.
<b>Step 7</b>	<b>redirect portal {ipv4   ipv6} ip-address</b>  <b>Example:</b> Device (config-params-parameter-map) # <code>redirect portal ipv4</code>	Configures the external portal IPv4 address.



	Command or Action	Purpose
<b>Step 8</b>	<b>end</b> <b>Example:</b> Device (config-params-parameter-map) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 9</b>	<b>show running-config   section parameter-map</b> <b>Example:</b> Device # <b>show running-config   section parameter-map</b>	Displays the configuration details.

**Example**

## Assigning Login, Login Failure, and Logout Pages per WLAN

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device # <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>parameter-map type webauth</b> <i>parameter-map-name</i> <b>Example:</b> Device (config) # <b>parameter-map type webauth test</b>	Configures the webauth type parameter.
<b>Step 3</b>	<b>custom-page login device</b> <i>html-filename</i> <b>Example:</b> Device (config-params-parameter-map) # <b>custom-page login device</b> device flash:login.html	Allows you to specify the filename for web authentication customized login page.
<b>Step 4</b>	<b>custom-page login expired</b> <i>html-filename</i> <b>Example:</b> Device (config-params-parameter-map) # <b>custom-page login expired</b> device flash:loginexpired.html	Allows you to specify the filename for web authentication customized login expiry page.
<b>Step 5</b>	<b>custom-page failure device</b> <i>html-filename</i> <b>Example:</b> Device (config-params-parameter-map) # <b>custom-page failure device</b> device flash:loginfail.html	Allows you to specify the filename for web authentication customized login failure page.

	Command or Action	Purpose
<b>Step 6</b>	<b>custom-page success device</b> <i>html-filename</i> <b>Example:</b> Device (config-params-parameter-map) # <b>custom-page success device</b> device flash:loginsuccess.html	Allows you to specify the filename for web authentication customized login success page.
<b>Step 7</b>	<b>end</b> <b>Example:</b> Device (config-params-parameter-map) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show running-config   section parameter-map</b> <b>type webauth</b> <i>parameter-map</i> <b>Example:</b> Device (config) # <b>show running-config</b> <b>  section parameter-map type webauth</b> test	Displays the configuration details.

### Example

## Configuring AAA-Override

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device # <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan</b> <i>wlan-name</i> <b>Example:</b> Device (config) # <b>wlan</b> ramban	For <i>wlan-name</i> , enter the profile name. The range is 1- 32 characters.
<b>Step 3</b>	<b>aaa-override</b> <b>Example:</b> Device (config-wlan) # <b>aaa-override</b>	Enables AAA override on the WLAN.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device (config-wlan) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show running-config   section</b> <i>wlan-name</i> <b>Example:</b>	Displays the configuration details.

	Command or Action	Purpose
	Device # <code>show running-config   section ramban</code>	

### Example

## Configuring Client Load Balancing

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>configure terminal</code> <b>Example:</b> Device # <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<code>wlan wlan-name</code> <b>Example:</b> Device (config)# <code>wlan ramban</code>	For <i>wlan-name</i> , enter the profile name.
<b>Step 3</b>	<code>shutdown</code> <b>Example:</b> Device (config-wlan)# <code>shutdown</code>	Disables WLAN.
<b>Step 4</b>	<code>mobility anchor ip-address1</code> <b>Example:</b> Device (config-wlan) # <code>mobility anchor 9.7.136.15</code>	Configures a guest controller as mobility anchor.
<b>Step 5</b>	<code>mobility anchor ip-address2</code> <b>Example:</b> Device (config-wlan) # <code>mobility anchor 9.7.136.16</code>	Configures a guest controller as mobility anchor.
<b>Step 6</b>	<code>no shutdown wlan</code> <b>Example:</b> Device (config-wlan) # <code>no shutdown wlan</code>	Enables the WLAN.
<b>Step 7</b>	<code>end</code> <b>Example:</b> Device (config-wlan) # <code>end</code>	Returns to privileged EXEC mode.
<b>Step 8</b>	<code>show running-config   section wlan-name</code> <b>Example:</b>	Displays the configuration details.

	Command or Action	Purpose
	Device # <code>show running-config   section ramban</code>	

### Example

## Configuring Preauthentication ACL

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan <i>wlan-name</i></b> <b>Example:</b> Device (config)# <code>wlan ramban</code>	For <i>wlan-name</i> , enter the profile name.
<b>Step 3</b>	<b>shutdown</b> <b>Example:</b> Device (config-wlan)# <code>shutdown</code>	Disables the WLAN.
<b>Step 4</b>	<b>ip access-group web <i>preauthrule</i></b> <b>Example:</b> Device (config-wlan)# <code>ip access-group web preauthrule</code>	Configures ACL that has to be applied before authentication.
<b>Step 5</b>	<b>no shutdown</b> <b>Example:</b> Device (config)# <code>no shutdown</code>	Enables the WLAN.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device (config-wlan)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show wlan name <i>wlan-name</i></b> <b>Example:</b> Device# <code>show wlan name ramban</code>	Displays the configuration details.

## Example

## Configuring IOS ACL Definition

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device # <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>ip access-list extended</b> <i>access-list number</i> <b>Example:</b> Device (config) # <code>ip access-list extended 102</code>	Configures extended IP access-list.
<b>Step 3</b>	<b>permit udp any eq</b> <i>port number any</i> <b>Example:</b> Device (config-ext-nacl) # <code>permit udp any eq 8080 any</code>	Configures destination host.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device (config-wlan) # <code>end</code>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show access-lists</b> <i>ACL number</i> <b>Example:</b> Device # <code>show access-lists 102</code>	Displays the configuration details.

## Example

## Configuring Webpassthrough

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device # <code>configure terminal</code>	Enters global configuration mode.

	Command or Action	Purpose
Step 2	<b>parameter-map type webauth</b> <i>parameter-map name</i> <b>Example:</b> Device (config) # <b>parameter-map type webauth</b> webparalocal	Configures the webauth type parameter.
Step 3	<b>type consent</b> <b>Example:</b> Device (config-params-parameter-map) # <b>type consent</b>	Configures webauth type as consent.
Step 4	<b>end</b> <b>Example:</b> Device (config-params-parameter-map) # <b>end</b>	Returns to privileged EXEC mode.
Step 5	<b>show running-config   section parameter-map type webauth</b> <i>parameter-map</i> <b>Example:</b> Device (config) # <b>show running-config   section parameter-map type webauth</b> test	Displays the configuration details.

### Example

## Configuration Examples for Guest Access

### Example: Creating a Lobby Ambassador Account

This example shows how to configure a lobby ambassador account.

```
Device# configure terminal
Device(config)# user-name lobby
Device(config)# type lobby-admin
Device(config)# password 0 lobby
Device(config)# end
Device# show running-config | section lobby
      user-name lobby
      creation-time 1351118727
      password 0 lobby
      type lobby-admin
```

### Example: Obtaining Web Authentication Certificate

This example shows how to obtain web authentication certificate.

```
Device# configure terminal
Device(config)# crypto pki import cert pkcs12 tftp://9.1.0.100/ldapserver-cert.p12 cisco
Device(config)# end
Device# show crypto pki trustpoints cert
Trustpoint cert:
  Subject Name:
    e=rkannajr@cisco.com
    cn=sthaliya-lnx
    ou=WNBU
    o=Cisco
    l=SanJose
    st=California
    c=US
    Serial Number (hex): 00
  Certificate configured.
Device# show crypto pki certificates cert
Certificate
  Status: Available
  Certificate Serial Number (hex): 04
  Certificate Usage: General Purpose
  Issuer:
    e=rkannajr@cisco.com
    cn=sthaliya-lnx
    ou=WNBU
    o=Cisco
    l=SanJose
    st=California
    c=US
  Subject:
    Name: ldapserver
    e=rkannajr@cisco.com
    cn=ldapserver
    ou=WNBU
    o=Cisco
    st=California
    c=US
  Validity Date:
    start date: 07:35:23 UTC Jan 31 2012
    end   date: 07:35:23 UTC Jan 28 2022
  Associated Trustpoints: cert ldap12
  Storage: nvram:rkannajrcisc#4.cer

CA Certificate
  Status: Available
  Certificate Serial Number (hex): 00
  Certificate Usage: General Purpose
  Issuer:
    e=rkannajr@cisco.com
    cn=sthaliya-lnx
    ou=WNBU
    o=Cisco
    l=SanJose
    st=California
    c=US
  Subject:
    e=rkannajr@cisco.com
    cn=sthaliya-lnx
    ou=WNBU
    o=Cisco
    l=SanJose
    st=California
    c=US
  Validity Date:
```

```

start date: 07:27:56 UTC Jan 31 2012
end   date: 07:27:56 UTC Jan 28 2022
Associated Trustpoints: cert ldap12 ldap
Storage: nvram:rkannajrcisc#OCA.cer

```

## Example: Displaying a Web Authentication Certificate

This example shows how to display a web authentication certificate.

```

Device# show crypto ca certificate verb
Certificate
Status: Available
Version: 3
Certificate Serial Number (hex): 2A9636AC00000000858B
Certificate Usage: General Purpose
Issuer:
cn=Cisco Manufacturing CA
o=Cisco Systems
Subject:
Name: WS-C3780-6DS-S-2037064C0E80
Serial Number: PID:WS-C3780-6DS-S SN:FOC1534X12Q
cn=WS-C3780-6DS-S-2037064C0E80
serialNumber=PID:WS-C3780-6DS-S SN:FOC1534X12Q
CRL Distribution Points:
http://www.cisco.com/security/pki/crl/cmca.crl
Validity Date:
start date: 15:43:22 UTC Aug 21 2011
end   date: 15:53:22 UTC Aug 21 2021
Subject Key Info:
Public Key Algorithm: rsaEncryption
RSA Public Key: (1024 bit)
Signature Algorithm: SHA1 with RSA Encryption
Fingerprint MD5: A310B856 A41565F1 1D9410B5 7284CB21
Fingerprint SHA1: 04F180F6 CA1A67AF 9D7F561A 2BB397A1 0F5EB3C9
X509v3 extensions:
X509v3 Key Usage: F0000000
    Digital Signature
    Non Repudiation
    Key Encipherment
    Data Encipherment
X509v3 Subject Key ID: B9EEB123 5A3764B4 5E9C54A7 46E6EECA 02D283F7
X509v3 Authority Key ID: DOC52226 AB4F4660 ECAE0591 C7DC5AD1 B047F76C
Authority Info Access:
Associated Trustpoints: CISCO_IDEVID_SUDI
Key Label: CISCO_IDEVID_SUDI

```

## Example: Configuring Guest User Accounts

This example shows how to configure a guest user account.

```

Device# configure terminal
Device(config)# user-name guest
Device(config-user-name)# password 0 guest
Device(config-user-name)# type network-user description guest guest-user lifetime year 1
month 10 day 3 hour 1 minute 5 second 30
Device(config-user-name)# end
Device# show aaa local netuser all

```



```

User-Name          : guest
Type               : guest
Password           : guest
Is_passwd_encrypted : No
Descriptio        : guest
Attribute-List     : Not-Configured
First-Login-Time   : Not-Logged-In
Num-Login          : 0
Lifetime           : 1 years 10 months 3 days 1 hours 5 mins 30 secs
Start-Time         : 20:47:37 chennai Dec 21 2012

```

## Example: Configuring Mobility Controller

This example shows how to configure a mobility controller.

```

Device# configure terminal
Device(config)# wireless mobility group member ip 27.0.0.1 public-ip 23.0.0.1 group test
Device(config)# wireless mobility controller peer-group pg
Device(config)# wireless mobility controller peer-group pg member ip 9.7.136.10 public-ip
9.7.136.10
Device(config)# end
Device# show wireless mobility summary

```

Mobility Controller Summary:

```

Mobility Role           : Mobility Controller
Mobility Protocol Port  : 16666
Mobility Group Name     : default
Mobility Oracle         : Enabled
DTLS Mode               : Enabled

Mobility Keepalive Interval : 10
Mobility Keepalive Count   : 3
Mobility Control Message DSCP Value : 7
Mobility Domain Member Count : 3

```

Link Status is Control Link Status : Data Link Status

Controllers configured in the Mobility Domain:

IP	Public IP	Group Name	Multicast IP	Link Status
9.9.9.2	-	default	0.0.0.0	UP : UP
12.12.11.11	12.13.12.12	rasagna-grp		DOWN : DOWN
27.0.0.1	23.0.0.1	test		DOWN : DOWN

```

Switch Peer Group Name : spg1
Switch Peer Group Member Count : 0
Bridge Domain ID       : 0
Multicast IP Address   : 0.0.0.0

```

```

Switch Peer Group Name : pg
Switch Peer Group Member Count : 1
Bridge Domain ID       : 0
Multicast IP Address   : 0.0.0.0

```

IP	Public IP	Link Status
9.7.136.10	9.7.136.10	DOWN : DOWN

## Example: Choosing the Default Web Authentication Login Page

This example shows how to choose a default web authentication login page.

```
Device# configure terminal
Device(config)# parameter-map type webauth test
This operation will permanently convert all relevant authentication commands to their CPL
control-policy equivalents. As this conversion is irreversible and will
disable the conversion CLI 'authentication display [legacy|new-style]', you are strongly
advised to back up your current configuration before proceeding.
Do you wish to continue? [yes]: yes
Device(config)# wlan wlan50
Device(config-wlan)# shutdown
Device(config-wlan)# security web-auth authentication-list test
Device(config-wlan)# security web-auth parameter-map test
Device(config-wlan)# no shutdown
Device(config-wlan)# end
Device# show running-config | section wlan50
wlan wlan50 50 wlan50
 security wpa akm cckm
 security wpa wpa1
 security wpa wpa1 ciphers aes
 security wpa wpa1 ciphers tkip
 security web-auth authentication-list test
 security web-auth parameter-map test
 session-timeout 1800
 no shutdown

Device# show running-config | section parameter-map type webauth test
parameter-map type webauth test
 type webauth
```

## Example: Choosing a Customized Web Authentication Login Page from an IPv4 External Web Server

This example shows how to choose a customized web authentication login page from an IPv4 external web server.

```
Device# configure terminal
Device(config)# parameter-map type webauth global
Device(config-params-parameter-map)# virtual-ip ipv4 1.1.1.1
Device(config-params-parameter-map)# parameter-map type webauth test
Device(config-params-parameter-map)# type webauth
Device(config-params-parameter-map)# redirect for-login http://9.1.0.100/login.html
Device(config-params-parameter-map)# redirect portal ipv4 9.1.0.100
Device(config-params-parameter-map)# end
Device# show running-config | section parameter-map
parameter-map type webauth global
virtual-ip ipv4 1.1.1.1
parameter-map type webauth test
type webauth
redirect for-login http://9.1.0.100/login.html
redirect portal ipv4 9.1.0.100
security web-auth parameter-map rasagna-auth-map
security web-auth parameter-map test
```

## Example: Assigning Login, Login Failure, and Logout Pages per WLAN

This example shows how to assign login, login failure and logout pages per WLAN.

```
Device# configure terminal
Device(config)# parameter-map type webauth test
Device(config-params-parameter-map)# custom-page login device flash:loginsantosh.html
Device(config-params-parameter-map)# custom-page login expired device flash:loginexpire.html
Device(config-params-parameter-map)# custom-page failure device flash:loginfail.html
Device(config-params-parameter-map)# custom-page success device flash:loginsuccess.html
Device(config-params-parameter-map)# end
Device# show running-config | section parameter-map type webauth test
parameter-map type webauth test
type webauth
redirect for-login http://9.1.0.100/login.html
redirect portal ipv4 9.1.0.100
custom-page login device flash:loginsantosh.html
custom-page success device flash:loginsuccess.html
custom-page failure device flash:loginfail.html
custom-page login expired device flash:loginexpire.html
```

## Example: Configuring AAA-Override

This example shows how to configure aaa-override.

```
Device# configure terminal
Device(config)# wlan fff
Device(config-wlan)# aaa-override
Device(config-wlan)# end
Device# show running-config | section fff
wlan fff 44 fff
aaa-override
shutdown
```

## Example: Configuring Client Load Balancing

This example shows how to configure client load balancing.

```
Device# configure terminal
Device(config)# wlan fff
Device(config-wlan)# shutdown
Device(config-wlan)# mobility anchor 9.7.136.15
Device(config-wlan)# mobility anchor 9.7.136.16
Device(config-wlan)# no shutdown wlan
Device(config-wlan)# end
Device# show running-config | section fff
wlan fff 44 fff
aaa-override
shutdown
```

## Example: Configuring Preauthentication ACL

This example shows how to configure preauthentication ACL.

```

Device# configure terminal
Device(config)# wlan fff
Device(config-wlan)# shutdown
Device(config-wlan)# ip access-group web preauthrule
Device(config-wlan)# no shutdown
Device(config-wlan)# end
Device# show wlan name fff

```

## Example: Configuring IOS ACL Definition

This example shows how to configure IOS ACL definition.

```

Device# configure terminal
Device(config)# ip access-list extended 102
Device(config-ext-nacl)# permit udp any eq 8080 any
Device(config-ext-nacl)# end
Device# show access-lists 102
Extended IP access list 102
  10 permit udp any eq 8080 any

```

## Example: Configuring Webpassthrough

This example shows how to configure webpassthrough.

```

Device# configure terminal
Device(config)# parameter-map type webauth webparalocal
Device(config-params-parameter-map)# type consent
Device(config-params-parameter-map)# end
Device# show running-config | section parameter-map type webauth test
parameter-map type webauth test
type webauth
redirect for-login http://9.1.0.100/login.html
redirect portal ipv4 9.1.0.100

```

## Additional References for Guest Access

### Related Documents

Related Topic	Document Title
Mobility CLI commands	<i>Mobility Command Reference, Cisco IOS XE 3SE (Cisco WLC 5700 Series)</i>
Mobility configuration	<i>Mobility Configuration Guide, Cisco IOS XE 3SE (Cisco WLC 5700 Series)</i>
Security CLI commands	<i>Security Command Reference, Cisco IOS Release 3SE (Cisco WLC 5700 Series)</i>
Configuring web-based authentication on the Catalyst 5700 Series Wireless Controller	<i>Security Configuration Guide, Cisco IOS Release 3SE (Cisco WLC 5700 Series)</i>

Related Topic	Document Title
Wired guest access configuration and commands	<i>Identity Based Networking Services</i>

#### Standards and RFCs

Standard/RFC	Title
None	-

#### MIBs

MIB	MIBs Link
None	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

#### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for Guest Access

Releases	Feature Information
Cisco IOS XE Release 3.2SE	This feature was introduced.





## CHAPTER 119

# Managing Rogue Devices

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## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Rogue Devices

Rogue access points can disrupt wireless LAN operations by hijacking legitimate clients and using plain-text or other denial-of-service or man-in-the-middle attacks. That is, a hacker can use a rogue access point to capture sensitive information, such as usernames and passwords. The hacker can then transmit a series of Clear to Send (CTS) frames. This action mimics an access point, informing a particular client to transmit, and instructing all the other clients to wait, which results in legitimate clients being unable to access network

resources. Wireless LAN service providers have a strong interest in banning rogue access points from the air space.

Because rogue access points are inexpensive and readily available, employees sometimes plug unauthorized rogue access points into existing LANs and build ad hoc wireless networks without their IT department's knowledge or consent. These rogue access points can be a serious breach of network security because they can be plugged into a network port behind the corporate firewall. Because employees generally do not enable any security settings on the rogue access point, it is easy for unauthorized users to use the access point to intercept network traffic and hijack client sessions. There is an increased chance of enterprise security breach when wireless users connect to access points in the enterprise network.

The following are some guidelines to manage rogue devices:

- The containment frames are sent immediately after the authorization and associations are detected. The enhanced containment algorithm provides more effective containment of ad hoc clients.
- The local mode access points are designed to serve associated clients. These access points spend relatively less time performing off-channel scanning: about 50 milliseconds on each channel. If you want to perform high rogue detection, a monitor mode access point must be used. Alternatively, you can reduce the scan intervals from 180 seconds to a lesser value, for example, 120 or 60 seconds, ensuring that the radio goes off-channel more frequently, which improves the chances of rogue detection. However, the access point continues to spend about 50 milliseconds on each channel.
- Rogue detection is disabled by default for OfficeExtend access points because these access points, which are deployed in a home environment, are likely to detect many rogue devices.
- Client card implementations might mitigate the effectiveness of ad hoc containment.
- It is possible to classify and report rogue access points by using rogue states and user-defined classification rules that enable rogues to automatically move between states.
- Each controller limits the number of rogue containments to three per radio (or six per radio for access points in the monitor mode).
- Rogue Location Discovery Protocol (RLDP) detects rogue access points that are configured for open authentication.
- RLDP detects rogue access points that use a broadcast Basic Service Set Identifier (BSSID), that is, the access point broadcasts its Service Set Identifier in beacons.
- RLDP detects only those rogue access points that are on the same network. If an access list in the network prevents the sending of RLDP traffic from the rogue access point to the controller, RLDP does not work.
- RLDP does not work on 5-GHz Dynamic Frequency Selection (DFS) channels. However, RLDP works when the managed access point is in the monitor mode on a DFS channel.
- If RLDP is enabled on mesh APs, and the APs perform RLDP tasks, the mesh APs are dissociated from the controller. The workaround is to disable RLDP on mesh APs.
- If RLDP is enabled on non-monitor APs, client connectivity outages occur when RLDP is in process.
- If the rogue is manually contained, the rogue entry is retained even after the rogue expires.
- If the rogue is contained by any other means, such as auto, rule, and AwIPS preventions, the rogue entry is deleted when it expires.
- The controller requests to the AAA server for rogue client validation only once. As a result, if rogue client validation fails on the first attempt then the rogue client will not be detected as a threat any more.



To avoid this, add the valid client entries in the authentication server before enabling **Validate Rogue Clients Against AAA**.

- In the 7.4 and earlier releases, if a rogue that was already classified by a rule was not reclassified. In the 7.5 release, this behavior is enhanced to allow reclassification of rogues based on the priority of the rogue rule. The priority is determined by using the rogue report that is received by the controller.
- The rogue detector AP fails to co-relate and contain the wired rogue AP on a 5Mhz channel because the MAC address of the rogue AP for WLAN, LAN, 11a radio and 11bg radio are configured with a difference of +/-1 of the rogue BSSID. In the 8.0 release, this behavior is enhanced by increasing the range of MAC address, that the rogue detector AP co-relates the wired ARP MAC and rogue BSSID, by +/-3.
- The rogue access points with open authentication can be detected on wire. The NAT wired or rogue wired detection is not supported in by WLC (both RLDP and rogue detector AP). The non-adjacent MAC address is supported by rogue detector mode of AP and not by RLDP.
- In a High Availability scenario, if the rogue detection security level is set to either High or Critical, the rogue timer on the standby controller starts only after the rogue detection pending stabilization time, which is 300 seconds. Therefore, the active configurations on the standby controller are reflected only after 300 seconds.
- After an AP is moved from rogue detection mode to any other mode or after an AP is moved from sniffer mode to local or monitor mode, the rogue detection functionality is not retained on the AP. To enable rogue detection functionality on the AP, you have to explicitly move the AP to the rogue detection mode.
- Some rogue devices exhibit RSSI value of -128 dBm although the minimum RSSI has been configured to a higher value. In some scenarios, APs show the RSSI value of 0 for some rogue devices. If the controller receives the RSSI value as 0, the controller invalidates the value and replaces it with -128 dBm so that rogue rules or policies are not applied to the rogue device.



---

**Note** A rogue AP or client or adhoc containment configuration is not saved after the reload. You have to configure all the rogues again after the reload.

---



---

**Note** No separate command exists for controlling rogue client traps. However, you can enable or disable rogue client traps using the **config trapflags rogueap {enable | disable}** command, which is also used for rogue APs. In GUI configuration also, you should use the rogue AP flag under **Management > SNMP > TrapControl > Security > Rogue AP** to control rogue clients.

---

### Restrictions on Rogue Detection

- Rogue containment on DFS channels is not supported.

### Rogue Location Discovery Protocol

Rogue Location Discovery Protocol (RLDP) is an active approach, which is used when rogue AP has no authentication (Open Authentication) configured. This mode, which is disabled by default, instructs an active AP to move to the rogue channel and connect to the rogue as a client. During this time, the active AP sends de-authentication messages to all connected clients and then shuts down the radio interface. Then, it associates

to the rogue AP as a client. The AP then tries to obtain an IP address from the rogue AP and forwards a User Datagram Protocol (UDP) packet (port 6352) that contains the local AP and rogue connection information to the controller through the rogue AP. If the controller receives this packet, the alarm is set to notify the network administrator that a rogue AP was discovered on the wired network with the RLDP feature.

RLDP has 100 % accuracy in rogue AP detection. It detects Open APs and NAT APs.




---

**Note** Use the **debug dot11 rldp enable** command in order to check if the Lightweight AP associates and receives a DHCP address from the rogue AP. This command also displays the UDP packet sent by the Lightweight AP to the controller.

---

A sample of a UDP (destination port 6352) packet sent by the Lightweight AP is shown here: 0020 0a 01 01 0d 0a 01 .....(\*..... 0030 01 1e 00 07 85 92 78 01 00 00 00 00 00 00 00 .....x..... 0040 00 00 00 00 00 00 00 00 00

The first 5 bytes of the data contain the DHCP address given to the local mode AP by the rogue AP. The next 5 bytes are the IP address of the controller, followed by 6 bytes that represent the rogue AP MAC address. Then, there are 18 bytes of zeroes.

The following steps describe the functioning of RLDP:

1. Identify the closest Unified AP to the rogue using signal strength values.
2. The AP then connects to the rogue as a WLAN client, attempting three associations before timing out.
3. If association is successful, the AP then uses DHCP to obtain an IP address.
4. If an IP address was obtained, the AP (acting as a WLAN client) sends a UDP packet to each of the controller's IP addresses.
5. If the controller receives even one of the RLDP packets from the client, that rogue is marked as on-wire.




---

**Note** The RLDP packets are unable to reach the controller if filtering rules are placed between the controller's network and the network where the rogue device is located.

---

Caveats of RLDP:

- RLDP only works with open rogue APs broadcasting their SSID with authentication and encryption disabled.
- RLDP requires that the Managed AP acting as a client is able to obtain an IP address via DHCP on the rogue network.
- Manual RLDP can be used to attempt an RLDP trace on a rogue multiple number of times.
- During RLDP process, the AP is unable to serve clients. This negatively impacts performance and connectivity for local mode APs. To avoid this case, RLDP can be selectively enabled for Monitor Mode AP only.
- RLDP does not attempt to connect to a rogue AP operating in a 5GHz DFS channel.



**Note** RLDP is not supported for use with Cisco autonomous rogue access points. These access points drop the DHCP Discover request sent by the RLDP client. Also, RLDP is not supported if the rogue access point channel requires dynamic frequency selection (DFS). If the automatic RLDP attempt does not detect the rogue (due to a noisy RF environment, for example), the controller does not retry. However, you can initiate RLDP manually on a rogue device.

### Detecting Rogue Devices

The controller continuously monitors all the nearby access points and automatically discovers and collects information on rogue access points and clients. When the controller discovers a rogue access point, it uses the Rogue Location Discovery Protocol (RLDP) and the rogue detector mode access point is connected to determine if the rogue is attached to your network.

Controller initiates RLDP on rogue devices that have open authenticated and configured. If RLDP uses FlexConnect or local mode access points, then clients are disconnected for that moment. After the RLDP cycle, the clients are reconnected to the access points. As and when rogue access points are seen (auto-configuration), the RLDP process is initiated.

You can configure the controller to use RLDP on all the access points or only on the access points configured for the monitor (listen-only) mode. The latter option facilitates automated rogue access point detection in a crowded radio frequency (RF) space, allowing monitoring without creating unnecessary interference and without affecting the regular data access point functionality. If you configure the controller to use RLDP on all the access points, the controller always chooses the monitor access point for RLDP operation if a monitor access point and a local (data) access point are both nearby. If RLDP determines that the rogue is on your network, you can choose to contain the detected rogue either manually or automatically.

RLDP detects on wire presence of the rogue access points that are configured with open authentication only once, which is the default retry configuration. Retries can be configured using the **config rogue ap rldp retries** command.

You can initiate or trigger RLDP from controller in three ways:

1. Enter the RLDP initiation command manually from the controller CLI. The equivalent GUI option for initiating RLDP is not supported.  
**config rogue ap rldp initiate** *mac-address*
2. Schedule RLDP from the controller CLI. The equivalent GUI option for scheduling RLDP is not supported.  
**config rogue ap rldp schedule**
3. Auto RLDP. You can configure auto RLDP on controller either from controller CLI or GUI but keep in mind the following guidelines:
  - The auto RLDP option can be configured only when the rogue detection security level is set to custom.
  - Either auto RLDP or schedule of RLDP can be enabled at a time.

A rogue access point is moved to a contained state either automatically or manually. The controller selects the best available access point for containment and pushes the information to the access point. The access point stores the list of containments per radio. For auto containment, you can configure the controller to use only the monitor mode access point. The containment operation occurs in the following two ways:

- The container access point goes through the list of containments periodically and sends unicast containment frames. For rogue access point containment, the frames are sent only if a rogue client is associated.
- Whenever a contained rogue activity is detected, containment frames are transmitted.

Individual rogue containment involves sending a sequence of unicast disassociation and deauthentication frames.

### Cisco Prime Infrastructure Interaction and Rogue Detection

Cisco Prime Infrastructure supports rule-based classification and uses the classification rules configured on the controller. The controller sends traps to Cisco Prime Infrastructure after the following events:

- If an unknown access point moves to the Friendly state for the first time, the controller sends a trap to Cisco Prime Infrastructure only if the rogue state is Alert. It does not send a trap if the rogue state is Internal or External.
- If a rogue entry is removed after the timeout expires, the controller sends a trap to Cisco Prime Infrastructure for rogue access points that are categorized as Malicious (Alert, Threat) or Unclassified (Alert). The controller does not remove rogue entries with the following rogue states: Contained, Contained Pending, Internal, and External.

## How to Configure Rogue Detection

### Configuring Rogue Detection (CLI)

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wireless wps rogue detection min-rssi rssi in dBm</b> <b>Example:</b> Device(config)# <b>wireless wps rogue detection min-rssi 100</b>	Specify the minimum RSSI value that rogues should have for APs to detect and for rogue entry to be created in the device.  Valid range for the rssi in dBm parameter is -128 dBm to -70 dBm, and the default value is -128 dBm.

	Command or Action	Purpose
		<p><b>Note</b> This feature is applicable to all the AP modes. There can be many rogues with very weak RSSI values that do not provide any valuable information in rogue analysis. Therefore, you can use this option to filter rogues by specifying the minimum RSSI value at which APs should detect rogues.</p>
<b>Step 3</b>	<p><b>wireless wps rogue detection min-transient-time</b> <i>time in seconds</i></p> <p><b>Example:</b></p> <pre>Device(config)# wireless wps rogue detection min-transient-time</pre>	<p>Specify the time interval at which rogues have to be consistently scanned for by APs after the first time the rogues are scanned.</p> <p>Valid range for the time in sec parameter is 120 seconds to 1800 seconds, and the default value is 0.</p> <p><b>Note</b> This feature is applicable to APs that are in monitor mode only.</p> <p>Using the transient interval values, you can control the time interval at which APs should scan for rogues. APs can also filter the rogues based on their transient interval values.</p> <p>This feature has the following advantages:</p> <ul style="list-style-type: none"> <li>• Rogue reports from APs to the controller are shorter</li> <li>• Transient rogue entries are avoided in the controller</li> <li>• Unnecessary memory allocation for transient rogues are avoided</li> </ul>
<b>Step 4</b>	<p><b>wireless wps rogue client</b> {aaa   mse}</p> <p><b>Example:</b></p> <pre>Device(config)# wireless wps rogue client aaa Device(config)# wireless wps rogue client mse</pre>	<p>Set the AAA server or local database, or the MSE to validate if rogue clients are valid clients.</p>
<b>Step 5</b>	<p><b>wireless wps rogue ap valid-client auto-contain</b></p> <p><b>Example:</b></p> <pre>Device(config)# wireless wps rogue ap valid-client auto-contain</pre>	<p>Specify to automatically contain a rogue access point to which trusted clients are associated.</p>

	Command or Action	Purpose
<b>Step 6</b>	<b>end</b>  <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Verifying Rogue Detection

This section describes the new command for rogue detection.

The following command can be used to verify rogue detection on the .

**Table 172: Verifying Rogue Detection Command**

Command	Purpose
<b>show wireless wps rogue ap summary</b>	Displays a list of all rogue access points detected by the .
<b>show wireless wps rogue client detailed</b> <i>client-mac</i>	Displays detailed information for a specific rogue client.
<b>show wireless wps rogue client summary</b>	Displays a list of all rogue clients detected by the .
<b>show nmosp capability</b>	Displays the NMSP capabilities.

**Table 173: Verifying Rogue Auto-Containment Information**

Command	Purpose
<b>show wireless wps rogue auto-contain</b>	Displays the rogue auto-containment information.

## Examples: Rogue Detection Configuration

This example shows how to configure the minimum RSSI that a detected rogue AP needs to be at, to have an entry created at the :

```
Device# configure terminal
Device(config)# wireless wps rogue detection min-rssi -100

Device(config)# end
Device# show wireless wps rogue client detailed/show wireless wps rogue ap summary
```

This example shows how to configure the classification interval:

```
Device# configure terminal
Device(config)# wireless wps rogue detection min-transient-time 500
```

```
Device(config)# end
Device# show wireless wps rogue client detailed/show wireless wps rogue ap summary
```

This example shows how to configure the MSE to validate if rogue clients are valid clients:

```
Device# configure terminal
Device(config)# wireless wps rogue client mse
Device(config)# end
Device# show wireless wps rogue client summary
```

This example shows how to automatically contain a rogue access point to which trusted clients are associated:

```
Device# configure terminal
Device(config)# wireless wps rogue ap valid-client auto-contain
Device(config)# end
Device# show wireless wps rogue ap summary
Device# show nmsp capability
```

## Additional References for Rogue Detection

### Related Documents

Related Topic	Document Title
Security commands	<i>Security Command Reference Guide, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i>

### Standards and RFCs

Standard/RFC	Title
None	—

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information For Performing Rogue Detection Configuration

Release	Feature Information
Cisco IOS XE 3.3SE	This feature was introduced.
Cisco IOS XE 3E	Rogue validation against MSE.

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Rogue Devices

Rogue access points can disrupt wireless LAN operations by hijacking legitimate clients and using plain-text or other denial-of-service or man-in-the-middle attacks. That is, a hacker can use a rogue access point to capture sensitive information, such as usernames and passwords. The hacker can then transmit a series of Clear to Send (CTS) frames. This action mimics an access point, informing a particular client to transmit, and instructing all the other clients to wait, which results in legitimate clients being unable to access network resources. Wireless LAN service providers have a strong interest in banning rogue access points from the air space.

Because rogue access points are inexpensive and readily available, employees sometimes plug unauthorized rogue access points into existing LANs and build ad hoc wireless networks without their IT department's



knowledge or consent. These rogue access points can be a serious breach of network security because they can be plugged into a network port behind the corporate firewall. Because employees generally do not enable any security settings on the rogue access point, it is easy for unauthorized users to use the access point to intercept network traffic and hijack client sessions. There is an increased chance of enterprise security breach when wireless users connect to access points in the enterprise network.

The following are some guidelines to manage rogue devices:

- The containment frames are sent immediately after the authorization and associations are detected. The enhanced containment algorithm provides more effective containment of ad hoc clients.
- The local mode access points are designed to serve associated clients. These access points spend relatively less time performing off-channel scanning: about 50 milliseconds on each channel. If you want to perform high rogue detection, a monitor mode access point must be used. Alternatively, you can reduce the scan intervals from 180 seconds to a lesser value, for example, 120 or 60 seconds, ensuring that the radio goes off-channel more frequently, which improves the chances of rogue detection. However, the access point continues to spend about 50 milliseconds on each channel.
- Rogue detection is disabled by default for OfficeExtend access points because these access points, which are deployed in a home environment, are likely to detect many rogue devices.
- Client card implementations might mitigate the effectiveness of ad hoc containment.
- It is possible to classify and report rogue access points by using rogue states and user-defined classification rules that enable rogues to automatically move between states.
- Each controller limits the number of rogue containments to three per radio (or six per radio for access points in the monitor mode).
- Rogue Location Discovery Protocol (RLDP) detects rogue access points that are configured for open authentication.
- RLDP detects rogue access points that use a broadcast Basic Service Set Identifier (BSSID), that is, the access point broadcasts its Service Set Identifier in beacons.
- RLDP detects only those rogue access points that are on the same network. If an access list in the network prevents the sending of RLDP traffic from the rogue access point to the controller, RLDP does not work.
- RLDP does not work on 5-GHz Dynamic Frequency Selection (DFS) channels. However, RLDP works when the managed access point is in the monitor mode on a DFS channel.
- If RLDP is enabled on mesh APs, and the APs perform RLDP tasks, the mesh APs are dissociated from the controller. The workaround is to disable RLDP on mesh APs.
- If RLDP is enabled on non-monitor APs, client connectivity outages occur when RLDP is in process.
- If the rogue is manually contained, the rogue entry is retained even after the rogue expires.
- If the rogue is contained by any other means, such as auto, rule, and AwIPS preventions, the rogue entry is deleted when it expires.
- The controller requests to the AAA server for rogue client validation only once. As a result, if rogue client validation fails on the first attempt then the rogue client will not be detected as a threat any more. To avoid this, add the valid client entries in the authentication server before enabling **Validate Rogue Clients Against AAA**.

- In the 7.4 and earlier releases, if a rogue that was already classified by a rule was not reclassified. In the 7.5 release, this behavior is enhanced to allow reclassification of rogues based on the priority of the rogue rule. The priority is determined by using the rogue report that is received by the controller.
- The rogue detector AP fails to co-relate and contain the wired rogue AP on a 5Mhz channel because the MAC address of the rogue AP for WLAN, LAN, 11a radio and 11bg radio are configured with a difference of +/-1 of the rogue BSSID. In the 8.0 release, this behavior is enhanced by increasing the range of MAC address, that the rogue detector AP co-relates the wired ARP MAC and rogue BSSID, by +/-3.
- The rogue access points with open authentication can be detected on wire. The NAT wired or rogue wired detection is not supported in by WLC (both RLDP and rogue detector AP). The non-adjacent MAC address is supported by rogue detector mode of AP and not by RLDP.
- In a High Availability scenario, if the rogue detection security level is set to either High or Critical, the rogue timer on the standby controller starts only after the rogue detection pending stabilization time, which is 300 seconds. Therefore, the active configurations on the standby controller are reflected only after 300 seconds.
- After an AP is moved from rogue detection mode to any other mode or after an AP is moved from sniffer mode to local or monitor mode, the rogue detection functionality is not retained on the AP. To enable rogue detection functionality on the AP, you have to explicitly move the AP to the rogue detection mode.
- Some rogue devices exhibit RSSI value of -128 dBm although the minimum RSSI has been configured to a higher value. In some scenarios, APs show the RSSI value of 0 for some rogue devices. If the controller receives the RSSI value as 0, the controller invalidates the value and replaces it with -128 dBm so that rogue rules or policies are not applied to the rogue device.




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**Note** A rogue AP or client or adhoc containment configuration is not saved after the reload. You have to configure all the rogues again after the reload.

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**Note** No separate command exists for controlling rogue client traps. However, you can enable or disable rogue client traps using the **config trapflags rogueap {enable | disable}** command, which is also used for rogue APs. In GUI configuration also, you should use the rogue AP flag under **Management > SNMP > TrapControl > Security > Rogue AP** to control rogue clients.

---

### Restrictions on Rogue Detection

- Rogue containment on DFS channels is not supported.

### Rogue Location Discovery Protocol

Rogue Location Discovery Protocol (RLDP) is an active approach, which is used when rogue AP has no authentication (Open Authentication) configured. This mode, which is disabled by default, instructs an active AP to move to the rogue channel and connect to the rogue as a client. During this time, the active AP sends de-authentication messages to all connected clients and then shuts down the radio interface. Then, it associates to the rogue AP as a client. The AP then tries to obtain an IP address from the rogue AP and forwards a User Datagram Protocol (UDP) packet (port 6352) that contains the local AP and rogue connection information to

the controller through the rogue AP. If the controller receives this packet, the alarm is set to notify the network administrator that a rogue AP was discovered on the wired network with the RLDP feature.

RLDP has 100 % accuracy in rouge AP detection. It detects Open APs and NAT APs.



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**Note** Use the **debug dot11 rldp enable** command in order to check if the Lightweight AP associates and receives a DHCP address from the rogue AP. This command also displays the UDP packet sent by the Lightweight AP to the controller.

---

A sample of a UDP (destination port 6352) packet sent by the Lightweight AP is shown here: 0020 0a 01 01 0d 0a 01 .....(\*..... 0030 01 1e 00 07 85 92 78 01 00 00 00 00 00 00 00 .....x..... 0040 00 00 00 00 00 00 00 00 00

The first 5 bytes of the data contain the DHCP address given to the local mode AP by the rogue AP. The next 5 bytes are the IP address of the controller, followed by 6 bytes that represent the rogue AP MAC address. Then, there are 18 bytes of zeroes.

The following steps describe the functioning of RLDP:

1. Identify the closest Unified AP to the rogue using signal strength values.
2. The AP then connects to the rogue as a WLAN client, attempting three associations before timing out.
3. If association is successful, the AP then uses DHCP to obtain an IP address.
4. If an IP address was obtained, the AP (acting as a WLAN client) sends a UDP packet to each of the controller's IP addresses.
5. If the controller receives even one of the RLDP packets from the client, that rogue is marked as on-wire.



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**Note** The RLDP packets are unable to reach the controller if filtering rules are placed between the controller's network and the network where the rogue device is located.

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Caveats of RLDP:

- RLDP only works with open rogue APs broadcasting their SSID with authentication and encryption disabled.
- RLDP requires that the Managed AP acting as a client is able to obtain an IP address via DHCP on the rogue network.
- Manual RLDP can be used to attempt an RLDP trace on a rogue multiple number of times.
- During RLDP process, the AP is unable to serve clients. This negatively impacts performance and connectivity for local mode APs. To avoid this case, RLDP can be selectively enabled for Monitor Mode AP only.
- RLDP does not attempt to connect to a rogue AP operating in a 5GHz DFS channel.



**Note** RLDP is not supported for use with Cisco autonomous rogue access points. These access points drop the DHCP Discover request sent by the RLDP client. Also, RLDP is not supported if the rogue access point channel requires dynamic frequency selection (DFS). If the automatic RLDP attempt does not detect the rogue (due to a noisy RF environment, for example), the controller does not retry. However, you can initiate RLDP manually on a rogue device.

### Detecting Rogue Devices

The controller continuously monitors all the nearby access points and automatically discovers and collects information on rogue access points and clients. When the controller discovers a rogue access point, it uses the Rogue Location Discovery Protocol (RLDP) and the rogue detector mode access point is connected to determine if the rogue is attached to your network.

Controller initiates RLDP on rogue devices that have open authenticated and configured. If RLDP uses FlexConnect or local mode access points, then clients are disconnected for that moment. After the RLDP cycle, the clients are reconnected to the access points. As and when rogue access points are seen (auto-configuration), the RLDP process is initiated.

You can configure the controller to use RLDP on all the access points or only on the access points configured for the monitor (listen-only) mode. The latter option facilitates automated rogue access point detection in a crowded radio frequency (RF) space, allowing monitoring without creating unnecessary interference and without affecting the regular data access point functionality. If you configure the controller to use RLDP on all the access points, the controller always chooses the monitor access point for RLDP operation if a monitor access point and a local (data) access point are both nearby. If RLDP determines that the rogue is on your network, you can choose to contain the detected rogue either manually or automatically.

RLDP detects on wire presence of the rogue access points that are configured with open authentication only once, which is the default retry configuration. Retries can be configured using the **config rogue ap rldp retries** command.

You can initiate or trigger RLDP from controller in three ways:

1. Enter the RLDP initiation command manually from the controller CLI. The equivalent GUI option for initiating RLDP is not supported.  
**config rogue ap rldp initiate** *mac-address*
2. Schedule RLDP from the controller CLI. The equivalent GUI option for scheduling RLDP is not supported.  
**config rogue ap rldp schedule**
3. Auto RLDP. You can configure auto RLDP on controller either from controller CLI or GUI but keep in mind the following guidelines:
  - The auto RLDP option can be configured only when the rogue detection security level is set to custom.
  - Either auto RLDP or schedule of RLDP can be enabled at a time.

A rogue access point is moved to a contained state either automatically or manually. The controller selects the best available access point for containment and pushes the information to the access point. The access point stores the list of containments per radio. For auto containment, you can configure the controller to use only the monitor mode access point. The containment operation occurs in the following two ways:

- The container access point goes through the list of containments periodically and sends unicast containment frames. For rogue access point containment, the frames are sent only if a rogue client is associated.
- Whenever a contained rogue activity is detected, containment frames are transmitted.

Individual rogue containment involves sending a sequence of unicast disassociation and deauthentication frames.

### Cisco Prime Infrastructure Interaction and Rogue Detection

Cisco Prime Infrastructure supports rule-based classification and uses the classification rules configured on the controller. The controller sends traps to Cisco Prime Infrastructure after the following events:

- If an unknown access point moves to the Friendly state for the first time, the controller sends a trap to Cisco Prime Infrastructure only if the rogue state is Alert. It does not send a trap if the rogue state is Internal or External.
- If a rogue entry is removed after the timeout expires, the controller sends a trap to Cisco Prime Infrastructure for rogue access points that are categorized as Malicious (Alert, Threat) or Unclassified (Alert). The controller does not remove rogue entries with the following rogue states: Contained, Contained Pending, Internal, and External.

## How to Configure Rogue Detection

### Configuring Rogue Detection (CLI)

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wireless wps rogue detection min-rssi rssi in dBm</b>  <b>Example:</b> Device(config)# <code>wireless wps rogue detection min-rssi 100</code>	Specify the minimum RSSI value that rogues should have for APs to detect and for rogue entry to be created in the device.  Valid range for the rssi in dBm parameter is -128 dBm to -70 dBm, and the default value is -128 dBm.

	Command or Action	Purpose
		<p><b>Note</b> This feature is applicable to all the AP modes. There can be many rogues with very weak RSSI values that do not provide any valuable information in rogue analysis. Therefore, you can use this option to filter rogues by specifying the minimum RSSI value at which APs should detect rogues.</p>
<b>Step 3</b>	<p><b>wireless wps rogue detection min-transient-time</b> <i>time in seconds</i></p> <p><b>Example:</b></p> <pre>Device(config)# wireless wps rogue detection min-transient-time</pre>	<p>Specify the time interval at which rogues have to be consistently scanned for by APs after the first time the rogues are scanned.</p> <p>Valid range for the time in sec parameter is 120 seconds to 1800 seconds, and the default value is 0.</p> <p><b>Note</b> This feature is applicable to APs that are in monitor mode only.</p> <p>Using the transient interval values, you can control the time interval at which APs should scan for rogues. APs can also filter the rogues based on their transient interval values.</p> <p>This feature has the following advantages:</p> <ul style="list-style-type: none"> <li>• Rogue reports from APs to the controller are shorter</li> <li>• Transient rogue entries are avoided in the controller</li> <li>• Unnecessary memory allocation for transient rogues are avoided</li> </ul>
<b>Step 4</b>	<p><b>wireless wps rogue client</b> {aaa   mse}</p> <p><b>Example:</b></p> <pre>Device(config)# wireless wps rogue client aaa Device(config)# wireless wps rogue client mse</pre>	<p>Set the AAA server or local database, or the MSE to validate if rogue clients are valid clients.</p>
<b>Step 5</b>	<p><b>wireless wps rogue ap valid-client auto-contain</b></p> <p><b>Example:</b></p> <pre>Device(config)# wireless wps rogue ap valid-client auto-contain</pre>	<p>Specify to automatically contain a rogue access point to which trusted clients are associated.</p>

	Command or Action	Purpose
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Verifying Rogue Detection

This section describes the new command for rogue detection.

The following command can be used to verify rogue detection on the .

**Table 174: Verifying Rogue Detection Command**

Command	Purpose
<b>show wireless wps rogue ap summary</b>	Displays a list of all rogue access points detected by the .
<b>show wireless wps rogue client detailed</b> <i>client-mac</i>	Displays detailed information for a specific rogue client.
<b>show wireless wps rogue client summary</b>	Displays a list of all rogue clients detected by the .
<b>show nmosp capability</b>	Displays the NMSP capabilities.

**Table 175: Verifying Rogue Auto-Containment Information**

Command	Purpose
<b>show wireless wps rogue auto-contain</b>	Displays the rogue auto-containment information.

## Examples: Rogue Detection Configuration

This example shows how to configure the minimum RSSI that a detected rogue AP needs to be at, to have an entry created at the :

```
Device# configure terminal
Device(config)# wireless wps rogue detection min-rssi -100

Device(config)# end
Device# show wireless wps rogue client detailed/show wireless wps rogue ap summary
```

This example shows how to configure the classification interval:

```
Device# configure terminal
Device(config)# wireless wps rogue detection min-transient-time 500
```

```
Device(config)# end
Device# show wireless wps rogue client detailed/show wireless wps rogue ap summary
```

This example shows how to configure the MSE to validate if rogue clients are valid clients:

```
Device# configure terminal
Device(config)# wireless wps rogue client mse
Device(config)# end
Device# show wireless wps rogue client summary
```

This example shows how to automatically contain a rogue access point to which trusted clients are associated:

```
Device# configure terminal
Device(config)# wireless wps rogue ap valid-client auto-contain
Device(config)# end
Device# show wireless wps rogue ap summary
Device# show nmsp capability
```

## Additional References for Rogue Detection

### Related Documents

Related Topic	Document Title
Security commands	<i>Security Command Reference Guide, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i>

### Standards and RFCs

Standard/RFC	Title
None	—

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>



**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information For Performing Rogue Detection Configuration

Release	Feature Information
Cisco IOS XE 3.3SE	This feature was introduced.
Cisco IOS XE 3E	Rogue validation against MSE.





## CHAPTER 120

# Classifying Rogue Access Points

- [Finding Feature Information, on page 2261](#)
- [Information About Classifying Rogue Access Points, on page 2261](#)
- [Restrictions on Classifying Rogue Access Points, on page 2264](#)
- [How to Classify Rogue Access Points, on page 2265](#)
- [Examples: Classifying Rogue Access Points, on page 2268](#)
- [Additional References for Classifying Rogue Access Points, on page 2268](#)
- [Feature History and Information For Classifying Rogue Access Points, on page 2269](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Classifying Rogue Access Points

The controller software enables you to create rules that can organize and display rogue access points as Friendly, Malicious, or Unclassified.

By default, none of the classification rules are used. You need to enable them. Therefore, all unknown access points are categorized as Unclassified. When you create or change a rule, configure conditions, and enable it, all rogue access points are then reclassified. Whenever you change a rule, it is applied to all the access points (friendly, malicious, and unclassified) in the Alert state only.

If you move any rogue or ad hoc rogue manually to unclassified and Alert state, it means that the rogue is moved to the default state. Rogue rules apply to all the rogues that are manually moved to unclassified and Alert state.

**Note**

- Rule-based rogue classification does not apply to ad hoc rogues and rogue clients.
- You can configure up to 64 rogue classification rules per controller.

When the controller receives a rogue report from one of its managed access points, it responds as follows:

- If the unknown access point is in the friendly MAC address list, the controller classifies the access point as Friendly.
- If the unknown access point is not in the friendly MAC address list, the controller starts applying the rogue classification rules to the access point.
- If the rogue is already classified as Malicious, Alert or Friendly, Internal or External, the controller does not reclassify it automatically. If the rogue is classified differently, the controller reclassifies it automatically only if the rogue is in the Alert state.
- If the rogue access point matches the configured rules criteria, the controller classifies the rogue based on the classification type configured for that rule.
- If the rogue access point does not match any of the configured rules, the rogue remains unclassified.

The controller repeats the previous steps for all the rogue access points.

- If the rogue access point is detected on the same wired network, the controller marks the rogue state as Threat and classifies it as Malicious automatically, even if there are no configured rules. You can then manually contain the rogue to change the rogue state to Contained. If the rogue access point is not available on the network, the controller marks the rogue state as Alert. You can then manually contain the rogue.
- If desired, you can manually move the access point to a different classification type and rogue state.

**Table 176: Classification Mapping**

<b>Rule-Based Classification Type</b>	<b>Rogue State</b>
Friendly	<ul style="list-style-type: none"> <li>• Internal—If the unknown access point is inside the network and poses no threat to WLAN security, you can manually configure it as Friendly, Internal. An example of this would be the access points in your lab network.</li> <li>• External—If the unknown access point is outside the network and poses no threat to WLAN security, you can manually configure it as Friendly, External. An example of this would be the access point in your neighboring coffee shop.</li> <li>• Alert—The unknown access point is moved to Alert if it is not in the neighbor list or in the user-configured friendly MAC list.</li> </ul>

Rule-Based Classification Type	Rogue State
Malicious	<ul style="list-style-type: none"> <li>• Alert—The unknown access point is moved to Alert if it is not in the neighbor list or in the user-configured friendly MAC list.</li> <li>• Threat—The unknown access point is found to be on the network and poses a threat to WLAN security.</li> <li>• Contained—The unknown access point is contained.</li> <li>• Contained Pending—The unknown access point is marked Contained, but the action is delayed due to unavailable resources.</li> </ul>
Unclassified	<ul style="list-style-type: none"> <li>• Pending—On first detection, the unknown access point is put in the Pending state for 3 minutes. During this time, the managed access points determine if the unknown access point is a neighbor access point.</li> <li>• Alert—The unknown access point is moved to Alert if it is not in the neighbor list or in the user-configured friendly MAC list.</li> <li>• Contained—The unknown access point is contained.</li> <li>• Contained Pending—The unknown access point is marked Contained, but the action is delayed due to unavailable resources.</li> </ul>

The classification and state of the rogue access points are configured as follows:

- From Known to Friendly, Internal
- From Acknowledged to Friendly, External
- From Contained to Malicious, Contained

As mentioned earlier, the controller can automatically change the classification type and rogue state of an unknown access point based on user-defined rules. Alternatively, you can manually move the unknown access point to a different classification type and rogue state.

**Table 177: Allowable Classification Type and Rogue State Transitions**

From	To
Friendly (Internal, External, Alert)	Malicious (Alert)
Friendly (Internal, External, Alert)	Unclassified (Alert)
Friendly (Alert)	Friendly (Internal, External)
Malicious (Alert, Threat)	Friendly (Internal, External)
Malicious (Contained, Contained Pending)	Malicious (Alert)
Unclassified (Alert, Threat)	Friendly (Internal, External)
Unclassified (Contained, Contained Pending)	Unclassified (Alert)
Unclassified (Alert)	Malicious (Alert)

If the rogue state is Contained, you have to uncontain the rogue access point before you can change the classification type. If you want to move a rogue access point from Malicious to Unclassified, you must delete the access point and allow the controller to reclassify it.

## Restrictions on Classifying Rogue Access Points

- Classifying Custom type rogues is tied to rogue rules. Therefore, it is not possible to manually classify a rogue as Custom. Custom class change can occur only when rogue rules are used.
- Some are sent for containment by rule and every 30 minutes for rogue classification change. For custom classification, the first trap does not contain the severity score because the trap has existed before the custom classification. The severity score is obtained from the subsequent trap that is generated after 30 minutes if the rogue is classified.
- Rogue rules are applied on every incoming new rogue report in the controller in the order of their priority.
- After a rogue satisfies a higher priority rule and is classified, it does not move down the priority list for the same report.
- Previously classified rogue gets re-classified on every new rogue report with the following restrictions:
  - Rogues which are classified as friendly by rule and whose state is set to ALERT, go through re-classification on receiving the new rogue report.
  - If a rogue is classified as friendly by the administrator manually, then the state is INTERNAL and it does not get re-classified on successive rogue reports.
  - If rogue is classified as malicious, irrespective of the state it does not get re-classified on subsequent rogue reports.
- Transition of the rogue's state from friendly to malicious is possible by multiple rogue rules if some attribute is missing in new rogue report.
- Transition of the rogue's state from malicious to any other classification is not possible by any rogue rule.
- If a rogue AP is classified as friendly, it means that the rogue AP exists in the vicinity, is a known AP, and need not be tracked. Therefore, all the rogue clients are either deleted or not tracked if they are associated with the friendly rogue AP.
- When service set identifiers (SSIDs) are defined as part of a rogue rule, and details of the rogue rule are displayed using the **show wireless wps rogue rule detailed** command, the output differs in Cisco IOS XE Release 3.7E and prior releases and Cisco IOS XE Denali 16.1.1 and later releases.

The following is sample output from the **show wireless wps rogue rule detailed** command in Cisco IOS XE Release 3.6E and prior releases:

```
Switch# show wireless wps rogue rule detailed test

Priority                : 1
Rule Name               : wpstest
State                  : Disabled
Type                   : Pending
Match Operation        : Any
Hit Count              : 0
Total Conditions       : 1
Condition :
```

```

type                               : Ssid
SSID Count                          : 2
SSID 1                              : ssid1
SSID 2                              : ssid2

```

The following is sample output from the **show wireless wps rogue rule detailed** command in Cisco IOS XE Denali 16.1.1 and later releases:

```

Switch# show wireless wps rogue rule detailed test

Priority                             : 1
Rule Name                           : wpstest
State                                : Disabled
Type                                 : Pending
Match Operation                      : Any
Hit Count                            : 0
Total Conditions                    : 1
Condition :
  type                               : Ssid
  SSID Count                          : 2
  SSID                                : ssid1
  SSID                                : ssid2

```

# How to Classify Rogue Access Points

## Configuring Rogue Classification Rules (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wireless wps rogue rule <i>rule-name</i> priority <i>priority</i></b> <b>Example:</b> Device(config)# <b>wireless wps rogue rule rule_3 priority 3</b>	Creates or enables a rule. While creating a rule, you must enter the priority for the rule.  <b>Note</b> After creating a rule, you can edit the rule and change the priority only for the rogue rules that are disabled. You cannot change the priority for the rogue rules that are enabled. While editing, changing the priority for a rogue rule is optional.
<b>Step 3</b>	<b>classify {friendly   malicious}</b> <b>Example:</b> Device(config)# <b>wireless wps rogue rule rule_3 priority 3</b>	Classifies a rule.

	Command or Action	Purpose
	Device (config-rule) # <b>classify friendly</b>	
<b>Step 4</b>	<p><b>condition</b> {<b>client-count</b> <i>condition_value</i>   <b>duration</b>   <b>encryption</b>   <b>infrastructure</b>   <b>rssi</b>   <b>ssid</b>}</p> <p><b>Example:</b></p> <pre>Device (config) # wireless wps rogue rule rule_3 priority 3  Device (config-rule) # condition client-count 5</pre>	<p>Adds the following conditions to a rule, which the rogue access point must meet:</p> <ul style="list-style-type: none"> <li>• <b>client-count</b>—Requires that a minimum number of clients be associated to the rogue access point. For example, if the number of clients associated to the rogue access point is greater than or equal to the configured value, the access point could be classified as Malicious. If you choose this option, enter the minimum number of clients to be associated to the rogue access point for the <i>condition_value</i> parameter. The valid range is from 1 to 10 (inclusive), and the default value is 0.</li> <li>• <b>duration</b>—Requires that the rogue access point be detected for a minimum period of time. If you choose this option, enter a value for the minimum detection period for the <i>condition_value</i> parameter. The valid range is from 0 to 3600 seconds (inclusive), and the default value is 0 seconds.</li> <li>• <b>encryption</b>—Requires that the advertised WLAN does not have encryption enabled.</li> <li>• <b>infrastructure</b>—Requires the SSID to be known to the controller.</li> <li>• <b>rssi</b>—Requires that the rogue access point have a minimum RSSI value. For example, if the rogue access point has an RSSI that is greater than the configured value, then the access point could be classified as malicious. If you choose this option, enter the minimum RSSI value for the <i>condition_value</i> parameter. The valid range is from -95 to -50 dBm (inclusive), and the default value is 0 dBm.</li> <li>• <b>ssid</b>—Requires the rogue access point to have a specific SSID. You should an SSID that is not managed by the controller. If you choose this option, enter the SSID for the <i>condition_value</i> parameter. The SSID is added to the user-configured SSID list.</li> </ul>



	Command or Action	Purpose
<b>Step 5</b>	<b>match {all   any}</b> <b>Example:</b> <pre>Device(config)# wireless wps rogue rule rule_3 priority 3 Device(config-rule)# match all</pre>	Specifies whether a detected rogue access point must meet all or any of the conditions specified by the rule for the rule to be matched and the rogue access point to adopt the classification type of the rule.
<b>Step 6</b>	<b>default</b> <b>Example:</b> <pre>Device(config)# wireless wps rogue rule rule_3 priority 3 Device(config-rule)# default</pre>	Sets a command to its default.
<b>Step 7</b>	<b>exit</b> <b>Example:</b> <pre>Device(config)# wireless wps rogue rule rule_3 priority 3 Device(config-rule)# exit Device(config)#</pre>	Exits the sub-mode.
<b>Step 8</b>	<b>shutdown</b> <b>Example:</b> <pre>Device(config)# wireless wps rogue rule rule_3 priority 3 Device(config-rule)# shutdown</pre>	Disables a particular rogue rule. In this example, the rule <b>rule_3</b> is disabled.
<b>Step 9</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 10</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 11</b>	<b>wireless wps rogue rule shutdown</b> <b>Example:</b> <pre>Device(config)# wireless wps rogue rule shutdown</pre>	Disables all the rogue rules.
<b>Step 12</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Examples: Classifying Rogue Access Points

This example shows how to create a rule that can organize and display rogue access points as Friendly:

```
Device# configure terminal
Device(config)# wireless wps rogue rule ap1 priority 1
Device(config-rule)# classify friendly
Device(config-rule)# end
```

This example shows how to apply a condition that a rogue access point must meet:

```
Device# configure terminal
Device(config)# wireless wps rogue rule ap1 priority 1
Device(config-rule)# condition client-count 5
Device(config-rule)# condition duration 1000
Device(config-rule)# end
```

## Additional References for Classifying Rogue Access Points

### Related Documents

Related Topic	Document Title
Security commands	<i>Security Command Reference Guide, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i>

### Standards and RFCs

Standard/RFC	Title
None	—

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information For Classifying Rogue Access Points

Release	Feature Information
Cisco IOS XE 3.3SE	This feature was introduced.





## CHAPTER 121

# Configuring wIPS

- [Finding Feature Information, on page 2271](#)
- [Information About wIPS, on page 2271](#)
- [How to Configure wIPS on an Access Point, on page 2278](#)
- [Monitoring wIPS Information, on page 2278](#)
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- [Feature History for Performing wIPS Configuration, on page 2279](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About wIPS

The Cisco Adaptive Wireless Intrusion Prevention System (wIPS) uses an advanced approach to wireless threat detection and performance management. It combines network traffic analysis, network device and topology information, signature-based techniques, and anomaly detection to deliver highly accurate and complete wireless threat prevention. With a fully infrastructure-integrated solution, you can continually monitor wireless traffic on both the wired and wireless networks and use that network intelligence to analyze attacks from many sources to accurately pinpoint and proactively prevent attacks, rather than wait until damage or exposure has occurred.

Cisco Adaptive wIPS is a part of the Cisco 3300 Series Mobility Services Engine (MSE), which centralizes the processing of intelligence collected by the continuous monitoring of Cisco Aironet APs. With Cisco Adaptive wIPS functionalities and Cisco Prime Infrastructure integration into the Cisco MSE, the wIPS can configure and monitor wIPS policies and alarms and report threats.



**Note** If your wIPS deployment consists of a Cisco WLC, access point, and Cisco MSE, you must set all the three entities to the UTC time zone.

Cisco Adaptive wIPS is not configured on the Cisco WLC. Instead, the Cisco Prime Infrastructure forwards the profile configuration to the wIPS service, which forwards the profile to the Cisco WLC. The profile is stored in flash memory on the Cisco WLC and sent to APs when they join the Cisco WLC. When an access point disassociates and joins another Cisco WLC, it receives the wIPS profile from the new Cisco WLC.

Local-mode APs with a subset of wIPS capabilities are referred to as Enhanced Local Mode access point or ELM AP. You can configure an access point to work in the wIPS mode if the AP is in any of the following modes:

- Monitor
- Local

The regular local mode AP is extended with a subset of wIPS capabilities. This feature enables you to deploy your APs to provide protection without needing a separate overlay network.

wIPS ELM has the limited capability of detecting off-channel alarms. AN AP periodically goes off-channel, and monitors the nonserving channels for a short duration, and triggers alarms if any attack is detected on the channel. But off-channel alarm detection is best effort, and it takes a longer time to detect attacks and trigger alarms, which might cause the ELM AP to intermittently detect an alarm and clear it because it is not visible. APs in any of the above modes can periodically send alarms based on the policy profile to the wIPS service through the Cisco WLC. The wIPS service stores and processes the alarms and generates SNMP traps. Cisco Prime Infrastructure configures its IP address as a trap destination to receive SNMP traps from the Cisco MSE.

This table lists all the SNMP trap controls and their respective traps. When a trap control is enabled, all the traps of that trap control are also enabled.



**Note** The Cisco WLC uses only SNMPv2 for SNMP trap transmission.

**Table 178: SNMP Trap Controls and Their Respective Traps**

Tab Name	Trap Control	Trap
General	Link (Port) Up/Down	linkUp, linkDown
	Spanning Tree	newRoot, topologyChange, stpInstanceNewRootTrap, stpInstanceTopologyChangeTrap
	Config Save	bsnDot11EssCreated, bsnDot11EssDeleted, bsnConfigSaved, ciscoLwappScheduledResetNotif, ciscoLwappClearResetNotif, ciscoLwappResetFailedNotif, ciscoLwappSysInvalidXmlConfig

Tab Name	Trap Control	Trap
AP	AP Register	bsnAPDisassociated, bsnAPAssociated
	AP Interface Up/Down	bsnAPIfUp, bsnAPIfDown
Client Traps	802.11 Association	bsnDot11StationAssociate
	802.11 Disassociation	bsnDot11StationDisassociate
	802.11 Deauthentication	bsnDot11StationDeauthenticate
	802.11 Failed Authentication	bsnDot11StationAuthenticateFail
	802.11 Failed Association	bsnDot11StationAssociateFail
	Exclusion	bsnDot11StationBlacklisted
	NAC Alert	cldcClientWlanProfileName, cldcClientIPAddress, cldcApMacAddress, cldcClientQuarantineVLAN, cldcClientAccessVLAN
Security Traps	User Authentication	bsnTooManyUnsuccessLoginAttempts, cLWAGuestUserLoggedIn, cLWAGuestUserLoggedOut
	RADIUS Servers Not Responding	bsnRADIUSServerNotResponding, ciscoLwappAAARadiusReqTimedOut
	WEP Decrypt Error	bsnWepKeyDecryptError
	Rogue AP	bsnAdhocRogueAutoContained, bsnRogueApAutoContained, bsnTrustedApHasInvalidEncryption, bsnMaxRogueCountExceeded, bsnMaxRogueCountClear, bsnApMaxRogueCountExceeded, bsnApMaxRogueCountClear, bsnTrustedApHasInvalidRadioPolicy, bsnTrustedApHasInvalidSsid, bsnTrustedApIsMissing
	SNMP Authentication	agentSnmpAuthenticationTrapFlag
	Multiple Users	multipleUsersTrap

Tab Name	Trap Control	Trap
Auto RF Profile Traps	Load Profile	bsnAPLoadProfileFailed
	Noise Profile	bsnAPNoiseProfileFailed
	Interference Profile	bsnAPInterferenceProfileFailed
	Coverage Profile	bsnAPCoverageProfileFailed
Auto RF Update Traps	Channel Update	bsnAPCurrentChannelChanged
	Tx Power Update	bsnAPCurrentTxPowerChanged
Mesh Traps	Child Excluded Parent	ciscoLwappMeshChildExcludedParent
	Parent Change	ciscoLwappMeshParentChange
	Authfailure Mesh	ciscoLwappMeshAuthorizationFailure
	Child Moved	ciscoLwappMeshChildMoved
	Excessive Parent Change	ciscoLwappMeshExcessiveParentChange
	Excessive Children	ciscoLwappMeshExcessiveChildren
	Poor SNR	ciscoLwappMeshAbateSNR, ciscoLwappMeshOnsetSNR
	Console Login	ciscoLwappMeshConsoleLogin
	Excessive Association	ciscoLwappMeshExcessiveAssociation
	Default Bridge Group Name	ciscoLwappMeshDefaultBridgeGroupName

The following are the trap descriptions for the traps mentioned in the *SNMP Trap Controls and Their Respective Traps* table:

- General Traps

- SNMP Authentication—The SNMPv2 entity has received a protocol message that is not properly authenticated.




---

**Note** When a user who is configured in SNMP V3 mode tries to access the Cisco WLC with an incorrect password, the authentication fails and a failure message is displayed. However, no trap logs are generated for the authentication failure.

---

- Link (Port) Up/Down—Link changes status from up or down.
- Link (Port) Up/Down—Link changes status from up or down.
- Multiple Users—Two users log in with the same ID.



- Rogue AP—Whenever a rogue access point is detected, this trap is sent with its MAC address; when a rogue access point that was detected earlier no longer exists, this trap is sent.
- Config Save—Notification that is sent when the Cisco WLC configuration is modified.
- Cisco AP Traps
  - AP Register—Notification sent when an access point associates or disassociates with the Cisco WLC.
  - AP Interface Up/Down—Notification sent when an access point interface (802.11X) status goes up or down.
- Client-Related Traps
  - 802.11 Association—Associate notification that is sent when a client sends an association frame.
  - 802.11 Disassociation—Disassociate notification that is sent when a client sends a disassociation frame.
  - 802.11 Deauthentication—Deauthenticate notification that is sent when a client sends a deauthentication frame.
  - 802.11 Failed Authentication—Authenticate failure notification that is sent when a client sends an authentication frame with a status code other than successful.
  - 802.11 Failed Association—Associate failure notification that is sent when the client sends an association frame with a status code other than successful.
  - Exclusion—Associate failure notification that is sent when a client is exclusion listed (blacklisted).




---

**Note** The maximum number of static blacklist entries that the APs can have is 340.

---

- Authentication—Authentication notification that is sent when a client is successfully authenticated.
- Max Clients Limit Reached—Notification that is sent when the maximum number of clients, defined in the Threshold field, are associated with the Cisco WLC.
- NAC Alert—Alert that is sent when a client joins an SNMP NAC-enabled WLAN.

This notification is generated when a client on NAC-enabled SSIDs completes Layer2 authentication to inform the NAC appliance about the client's presence. `cldcClientWlanProfileName` represents the profile name of the WLAN that the 802.11 wireless client is connected to, `cldcClientIPAddress` represents the unique IP address of the client. `cldcApMacAddress` represents the MAC address of the AP to which the client is associated. `cldcClientQuarantineVLAN` represents the quarantine VLAN for the client. `cldcClientAccessVLAN` represents the access VLAN for the client.

- Association with Stats—Associate notification that is sent with data statistics when a client is associated with the Cisco WLC, or roams. Data statistics include transmitted and received bytes and packets.
- Disassociation with Stats—Disassociate notification that is sent with data statistics when a client disassociates from the Cisco WLC. Data statistics include transmitted and received bytes and packets, SSID, and session ID.



---

**Note** When you downgrade to Release 7.4 from a later release, if a trap that was not supported in Release 7.4 (for example, NAC Alert trap) is enabled before the downgrade, all traps are disabled. After the downgrade, you must enable all the traps that were enabled before the downgrade. We recommend that you disable the new traps before the downgrade so that all the other traps are not disabled.

---

- Security Traps

- User Auth Failure—This trap informs that a client RADIUS Authentication failure has occurred.
- RADIUS Server No Response—This trap is to indicate that no RADIUS servers are responding to authentication requests sent by the RADIUS client.
- WEP Decrypt Error—Notification sent when the Cisco WLC detects a WEP decrypting error.
- Rouge AP—Whenever a rogue access point is detected, this trap is sent with its MAC address; when a rogue access point that was detected earlier no longer exists, this trap is sent.
- SNMP Authentication—The SNMPv2 entity has received a protocol message that is not properly authenticated.



---

**Note** When a user who is configured in SNMP V3 mode tries to access the Cisco WLC with an incorrect password, authentication fails and a failure message is displayed. However, no trap logs are generated for the authentication failure.

---

- Multiple Users—Two users log in with the same ID.

- SNMP Authentication

- Load Profile—Notification sent when the Load Profile state changes between PASS and FAIL.
- Noise Profile—Notification sent when the Noise Profile state changes between PASS and FAIL.
- Interference Profile—Notification sent when the Interference Profile state changes between PASS and FAIL.
- Coverage Profile—Notification sent when the Coverage Profile state changes between PASS and FAIL.

- Auto RF Profile Traps

- Load Profile—Notification sent when the Load Profile state changes between PASS and FAIL.
- Noise Profile—Notification sent when the Noise Profile state changes between PASS and FAIL.
- Interference Profile—Notification sent when the Interference Profile state changes between PASS and FAIL.
- Coverage Profile—Notification sent when the Coverage Profile state changes between PASS and FAIL.

- Auto RF Update Traps
  - Channel Update—Notification sent when the access point dynamic channel algorithm is updated.
  - Tx Power Update—Notification sent when the access point dynamic transmit power algorithm is updated.
- Mesh Traps
  - Child Excluded Parent—Notification that is sent when a defined number of failed association to the Cisco WLC occurs through a parent mesh node.
  - Notification sent when a child mesh node exceeds the threshold limit of the number of discovery response timeouts. The child mesh node does not try to associate an excluded parent mesh node for the interval defined. The child mesh node remembers the excluded parent MAC address when it joins the network, and informs the Cisco WLC.
  - Parent Change—Notification is sent by the agent when a child mesh node changes its parent. The child mesh node remembers previous parent and informs the Cisco WLC about the change of parent when it rejoins the network.
  - Child Moved—Notification sent when a parent mesh node loses connection with its child mesh node.
  - Excessive Parent Change—Notification sent when the child mesh node changes its parent frequently. Each mesh node keeps a count of the number of parent changes in a fixed time. If it exceeds the defined threshold, the child mesh node informs the Cisco WLC.
  - Excessive Children—Notification sent when the child count exceeds for a RAP and a MAP.
  - Poor SNR—Notification sent when the child mesh node detects a lower SNR on a backhaul link. For the other trap, a notification is sent to clear a notification when the child mesh node detects an SNR on a backhaul link that is higher than the object defined by 'clMeshSNRThresholdAbate'.
  - Console Login—Notification is sent by the agent when a login on a MAP console is either successful or fail after three attempts.
  - Default Bridge Group Name—Notification sent when the MAP mesh node joins its parent using the default bridge group name.



---

**Note** The remaining traps do not have trap controls. These traps are not generated too frequently and do not require any trap control. Any other trap that is generated by the Cisco WLC cannot be turned off.

---



---

**Note** In all of the above cases, the Cisco WLC functions solely as a forwarding device.

---

# How to Configure wIPS on an Access Point

## Configuring wIPS on an Access Point (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>ap name</b> <i>name</i> <b>mode</b> <i>submode</i> <i>wips</i> <b>Example:</b> Device# <b>ap name ap1 mode local wips</b>	Configure an access point for local or monitor mode and then set the submode to wIPS.
<b>Step 2</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 3</b>	<b>show wireless wps wips summary</b> <b>Example:</b> Device# <b>show wireless wps wips summary</b>	View the wIPS configuration on the access point.
<b>Step 4</b>	<b>show wireless wps wips statistics</b> <b>Example:</b> Device# <b>show wireless wps wips statistics</b>	View the current state of wIPS configuration.

## Monitoring wIPS Information

This section describes the new command for wIPS.

The following command can be used to monitor wIPS configured on the access point.

**Table 179: Monitoring wIPS Command**

Command	Purpose
<b>show wireless wps wips summary</b>	Displays the wIPS configuration on the access point.
<b>show wireless wps wips statistics</b>	Displays the current state of wIPS configuration.

## Examples: wIPS Configuration

This example shows how to configure wIPS on AP1:

```
Device# ap name ap1 mode local submode wips
```

```
Device# end
Device# show wireless wps wips summary
```

## Additional References for Configuring wIPS

### Related Documents

Related Topic	Document Title
wIPS commands	<i>Security Command Reference Guide, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i>

### Standards and RFCs

Standard/RFC	Title
None	—

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History for Performing wIPS Configuration

Release	Feature Information
Cisco IOS XE 3.3SE	This feature was introduced.





## CHAPTER 122

# Configuring Intrusion Detection System

- [Finding Feature Information, on page 2281](#)
- [Information About Intrusion Detection System, on page 2281](#)
- [How to Configure Intrusion Detection System, on page 2282](#)
- [Monitoring Intrusion Detection System, on page 2283](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the <TBD>

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Intrusion Detection System

The Cisco Intrusion Detection System/Intrusion Prevention System (CIDS/CIPS) instructs devices to block certain clients from accessing the wireless network when attacks involving these clients are detected at Layer 3 through Layer 7. This system offers significant network protection by helping to detect, classify, and stop threats including worms, spyware/adware, network viruses, and application abuse. Two methods are available to detect potential attacks:

- IDS sensors
- IDS signatures

IDS sensors can be configured to detect various types of IP-level attacks in the network. When the sensors identify an attack, they can alert the device to shun the offending client. When a new IDS sensor is added, the IDS sensor should be registered with the device so that the device can query the sensor to get the list of shunned clients.

When an IDS sensor detects a suspicious client, it alerts the device to shun this client. The shun entry is distributed to all devices within the same mobility group. If the client to be shunned is currently joined to a device in this mobility group, the anchor device adds this client to the dynamic exclusion list, and the foreign

device removes the client. The next time that the client tries to connect to a device, the anchor device rejects the handoff and informs the foreign device that the client is being excluded.

# How to Configure Intrusion Detection System

## Configuring IDS Sensors

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wireless wps cids-sensor index</b> <b>[ip-address ip-addr username username</b> <b>password password_type password]</b> <b>Example:</b> Device(config)# <b>wireless wps cids-sensor</b> <b>2 231.1.1.1 admin pwd123</b>	Configures the IDS sensors that holds and internal index number. The index parameter determines the sequence in which the controller consults the IDS sensors. The controller supports up to five IDS sensors. <ul style="list-style-type: none"> <li>• <b>ip-address</b>– [optional] Provide the IP address for the IDS.</li> <li>• <b>username</b>– [optional] Configures the username for the IDS.</li> <li>• <b>password</b>– [optional] Configures the password for the respective username.</li> </ul>
<b>Step 3</b>	<b>wireless wps cids-sensor index</b> <b>Example:</b> Device(config)# <b>wireless wps cids-sensor</b> <b>1</b>	Enters the IDS configuration submode.
<b>Step 4</b>	<b>[default exit fingerprint interval no</b> <b>port shutdown]</b> <b>Example:</b> Device(config-cids-index)# <b>default</b>	Configures various IDS parameters. <ul style="list-style-type: none"> <li>• <b>default</b>– [optional] Sets a command to its default.</li> <li>• <b>exit</b>– [optional] Exits the submode.</li> <li>• <b>fingerprint</b>– [optional] Configures the sensor's TLS fingerprint.</li> <li>• <b>interval</b>– [optional] Configures the sensor's query interval. The range is between 10-3600 seconds.</li> </ul>



	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>no</b>– [optional] Negates a command or set its defaults.</li> <li>• <b>port</b>– [optional] Configures the sensor's port number.</li> <li>• <b>shutdown</b>– [optional] Shuts down the intrusion detection sensor.</li> </ul>
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config) # <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Monitoring Intrusion Detection System

*Table 180: Commands for Monitoring Wireless Multicast*

Commands	Description
<b>show wireless wps cids-sensor</b> <i>index</i>	Displays the IDS configuration of the IDS sensor with the mentioned index value.
<b>show wireless wps cids-sensor summary</b>	Displays the list of all the configured IDS with their respective values like index, ip-address, port number, interval value, status and last query.
<b>show wireless wps shun-list</b>	Displays the list of the IDS shun list.





## PART XVIII

### Stack Manager and High Availability

- [Managing Switch Stacks, on page 2287](#)
- [Configuring Cisco NSF with SSO , on page 2319](#)
- [Configuring Cisco StackWise Virtual, on page 2333](#)
- [Configuring Wireless High Availability, on page 2349](#)





## CHAPTER 123

# Managing Switch Stacks

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- [Prerequisites for Switch Stacks, on page 2287](#)
- [Restrictions for Switch Stacks, on page 2287](#)
- [Information About Switch Stacks, on page 2288](#)
- [How to Configure a Switch Stack, on page 2301](#)
- [Troubleshooting the Switch Stack, on page 2307](#)
- [Monitoring the Device Stack, on page 2309](#)
- [Configuration Examples for Switch Stacks, on page 2309](#)
- [Additional References for Switch Stacks, on page 2316](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Switch Stacks

All the switches in the switch stack need to be running the same license level as the active switch. For information about license levels, see the *System Management Configuration Guide (Catalyst 3850 Switches)*.

All switches in the switch stack need to be running compatible software versions.

## Restrictions for Switch Stacks

The following are restrictions for your switch stack configuration:

- Switch stacks running the LAN Base license level do not support Layer 3 features.

- A switch stack can have up to nine stacking-capable switches connected through their StackWise-480 ports.
- You cannot have a switch stack containing a mix of Catalyst 3850 and Catalyst 3650 switches.
- You cannot have a switch stack containing a mix of different license levels.



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**Note** In a mixed stack configuration, there is limited support for some features. For more information about a specific feature, see the relevant Catalyst 3850 configuration guide.

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# Information About Switch Stacks

## Switch Stack Overview

A switch stack can have up to nine stacking-capable switches connected through their StackWise-480 ports. The stack members work together as a unified system. Layer 2 and Layer 3 protocols present the entire switch stack as a single entity to the network.

A switch stack always has one active switch and one standby switch. If the active switch becomes unavailable, the standby switch assumes the role of the active switch, and continues to keep the stack operational.

The active switch controls the operation of the switch stack, and is the single point of stack-wide management. From the active switch, you configure:

- System-level (global) features that apply to all stack members
- Interface-level features for each stack member

The active switch contains the saved and running configuration files for the switch stack. The configuration files include the system-level settings for the switch stack and the interface-level settings for each stack member. Each stack member has a current copy of these files for back-up purposes.

A switch stack can have up to nine stacking-capable switches connected through their StackWise-480 ports. The switches in the stack must be homogeneous and must have the same license level.

## Supported Features in a Switch Stack

The system-level features supported on the active switch are supported on the entire switch stack.

### Encryption Features

If the active switch is running the cryptographic universal software image (supports encryption), the encryption features are available on the switch stack.

### StackWise-480

The stack members use the StackWise-480 technology to work together as a unified system. Layer 2 and Layer 3 protocols support the entire switch stack as a single entity in the network.



**Note** Switch stacks running the LAN Base image do not support Layer 3 features.

StackWise-480 has a stack bandwidth of 480 Gbps, and uses stateful switchover (SSO) to provide resiliency within the stack. The stack behaves as a single switching unit that is managed by an active switch elected by the member switches. The active switch automatically elects a standby switch within the stack. The active switch creates and updates all the switching, routing and wireless information and constantly synchronizes that information with the standby switch. If the active switch fails, the standby switch assumes the role of the active switch and continues to keep the stack operational. Access points continue to remain connected during an active-to-standby switchover unless the access point is directly connected to the active switch. In this case the access point will lose power and reboot. A working stack can accept new members or delete old ones without service interruption.

### Fast Stack Convergence

When a single link in a full ring stack becomes inoperable, there is a disruption in the forwarding of packets, and the stack moves to a half ring. With Catalyst 3850 switches this disruption of traffic (or stack convergence time) takes milliseconds.

### StackPower

StackPower allows the power supplies in a stack to be shared as a common resource among all the switches in the stack. StackPower unifies the individual power supplies installed in the switches and creates a pool of power, directing that power where it is needed. Up to four switches can be configured in a StackPower stack using the StackPower cable.

For more information about StackPower, see the *Interface and Hardware Component Configuration Guide (Catalyst 3850 Switches)*.

## Switch Stack Membership

A standalone device is a device stack with one stack member that also operates as the active switch. You can connect one standalone device to another to create a device stack containing two stack members, with one of them as the active switch. You can connect standalone devices to an existing device stack to increase the stack membership.

Hello messages are sent and received by all stack members.

- If a stack member does not respond, that member is removed from the stack.
- If the standby device does not respond, a new standby device is elected.
- If the active device does not respond, the standby device becomes the active device.

In addition, keepalive messages are sent and received between the active and standby devices.

- If the standby device does not respond, a new standby device is elected.
- If the active device does not respond, the standby device becomes the active device.

## Changes to Switch Stack Membership

If you replace a stack member with an identical model, the new switch functions with exactly the same configuration as the replaced switch, assuming that the new switch (referred to as the provisioned switch) is using the same member number as the replaced switch.

The operation of the switch stack continues uninterrupted during membership changes unless you remove the active switch or you add powered-on standalone switches or switch stacks.

- Adding powered-on switches (merging) causes all switches to reload and elect a new active switch from among themselves. The newly elected active switch retains its role and configuration. All other switches retain their stack member numbers and use the stack configuration of the newly elected active switch.




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**Note** In Cisco IOS XE 3.6.4E and later versions, when a new switch is powered-on as a standalone switch before it is added as part of the switch stack, only this switch is reloaded and not the whole switch stack.

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- Removing powered-on stack members causes the switch stack to divide (partition) into two or more switch stacks, each with the same configuration. This can cause:
  - An IP address conflict in your network. If you want the switch stacks to remain separate, change the IP address or addresses of the newly created switch stacks.
  - A MAC address conflict between two members in the stack. You can use the **stack-mac update force** command to resolve the conflict.

If a newly created switch stack does not have an active switch or standby switch, the switch stack will reload and elect a new active switch.




---

**Note** Make sure that you power off the switches that you add to or remove from the switch stack.

After adding or removing stack members, make sure that the switch stack is operating at full bandwidth (480 Gbps). Press the Mode button on a stack member until the Stack mode LED is on. The last two right port LEDs on all switches in the stack should be green. Depending on the switch model, the last two right ports are 10-Gigabit Ethernet ports or small form-factor pluggable (SFP) module ports (10/100/1000 ports). If one or both of these LEDs are not green on any of the switches, the stack is not operating at full bandwidth.

---

If you remove powered-on members but do not want to partition the stack:

- Power off the switches in the newly created switch stacks.
- Reconnect them to the original switch stack through their stack ports.
- Power on the switches.

For cabling and power considerations that affect switch stacks, see the *Catalyst 3850 Switch Hardware Installation Guide*.



## Stack Member Numbers

The stack member number (1 to 9) identifies each member in the stack. The member number also determines the interface-level configuration that a stack member uses. You can display the stack member number by using the **show switch EXEC** command.

A new, out-of-the-box (one that has not joined a stack or has not been manually assigned a stack member number) ships with a default stack member number of 1. When it joins a stack, its default stack member number changes to the lowest available member number in the stack.

Stack members in the same stack cannot have the same stack member number. Every stack member, including a standalone, retains its member number until you manually change the number or unless the number is already being used by another member in the stack.

- If you manually change the stack member number by using the **switch current-stack-member-number renumber new-stack-member-number EXEC** command, the new number goes into effect after that stack member resets (or after you use the **reload slot stack-member-number** privileged EXEC command) and only if that number is not already assigned to any other members in the stack. Another way to change the stack member number is by changing the `_NUMBER` environment variable.

If the number is being used by another member in the stack, the switch selects the lowest available number in the stack.

If you manually change the number of a stack member and no interface-level configuration is associated with that new member number, that stack member resets to its default configuration.

You cannot use the **switch current-stack-member-number renumber new-stack-member-number EXEC** command on a provisioned switch. If you do, the command is rejected.

- If you move a stack member to a different stack, the stack member retains its number only if the number is not being used by another member in the stack. If it is being used, the switch selects the lowest available number in the stack.
- If you merge stacks, the switches that join the stack of a new active switch select the lowest available numbers in the stack.

As described in the hardware installation guide, you can use the port LEDs in Stack mode to visually determine the stack member number of each stack member.

In the **default** mode Stack LED will blink in green color only on the stack master. However, when we scroll the Mode button to **Stack** option - Stack LED will glow green on all the stack members.

When mode button is scrolled to **Stack** option, the switch number of each stack member will be displayed as LEDs on the first five ports of that switch. The switch number is displayed in binary format for all stack members. On the switch, the amber LED indicates value 0 and green LED indicates value 1.

Example for switch number 5 (Binary - 00101):

First five LEDs glow as follows on stack member with switch number 5.

- Port-1 : Amber
- Port-2 : Amber
- Port-3 : Green
- Port-4 : Amber
- Port-5 : Green

Similarly, the first five LEDs glow amber or green, depending on the switch number on all stack members.

**Note**

- If you connect a Horizontal stack port to a normal network port on other end, stack port transmission/reception will be disabled within 30 seconds if no SDP packets are received from the other end.
- Stack port will not go down but only transmission/reception will be disabled. The log message shown below will be displayed on the console. Once the peer end network port is converted to stack port, transmission/reception on this stack port will be enabled.

```
%STACKMGR-4-HSTACK_LINK_CONFIG: Verify peer stack port setting for hstack
StackPort-1 switch 5 (hostname-switchnumber)
```

## Stack Member Priority Values

A higher priority value for a stack member increases the probability of it being elected active switch and retaining its stack member number. The priority value can be 1 to 15. The default priority value is 1. You can display the stack member priority value by using the **show switch EXEC** command.

**Note**

We recommend assigning the highest priority value to the device that you prefer to be the active switch. This ensures that the device is reelected as the active switch if a reelection occurs.

To change the priority value for a stack member, use the **switch stack-member-number priority new priority-value EXEC** command. For more information, see the “Setting the Stack Member Priority Value” section.

The new priority value takes effect immediately but does not affect the current active switch. The new priority value helps determine which stack member is elected as the new active switch when the current active switch or the switch stack resets.

## Switch Stack Bridge ID and MAC Address

A switch stack is identified in the network by its *bridge ID* and, if it is operating as a Layer 3 device, its router MAC address. The bridge ID and router MAC address are determined by the MAC address of the active switch.

If the active switch changes, the MAC address of the new active switch determines the new bridge ID and router MAC address.

If the entire switch stack reloads, the switch stack uses the MAC address of the active switch.

## Persistent MAC Address on the Switch Stack

You can use the persistent MAC address feature to set a time delay before the stack MAC address changes. During this time period, if the previous active switch rejoins the stack, the stack continues to use its MAC address as the stack MAC address, even if the switch is now a stack member and not an active switch. If the previous active switch does not rejoin the stack during this period, the switch stack takes the MAC address

of the new active switch as the stack MAC address. By default, the stack MAC address will be the MAC address of the first active switch, even if a new active switch takes over.

You can use the persistent MAC address feature to set a time delay before the stack MAC address changes to the MAC address of the new stack master. When this feature is enabled, the stack MAC address changes in approximately 4 minutes. During this time, if the previous stack master rejoins the stack, the stack continues to use its MAC address as the stack MAC address, even if the switch is now a stack member and not a stack master. If the previous stack master does not rejoin the stack during this period, the switch stack takes the MAC address of the new stack master as the stack MAC address.

You can also configure stack MAC persistency so that the stack MAC address never changes to the new active switch MAC address.

## Active and Standby Switch Election and Reelection

All stack members are eligible to be the active switch or the standby switch. If the active switch becomes unavailable, the standby switch becomes the active switch.

An active switch retains its role unless one of these events occurs:

- The switch stack is reset.
- The active switch is removed from the switch stack.
- The active switch is reset or powered off.
- The active switch fails.
- The switch stack membership is increased by adding powered-on standalone switches or switch stacks.

All stack members are eligible stack masters. If the stack master becomes unavailable, the remaining members elect a new stack master from among themselves.

The active switch is elected or reelected based on one of these factors and in the order listed:

1. The switch that is currently the active switch.
2. The switch with the highest stack member priority value.



---

**Note**

We recommend assigning the highest priority value to the switch that you prefer to be the active switch. This ensures that the switch is reelected as active switch if a reelection occurs.

---

3. The switch with the shortest start-up time. Differences in start-up times between the feature image licenses determine the active switch. For example, a switch running the IP Services license level has a higher priority than the switch running the IP Base license level, but the switch running the IP Base license level becomes the active switch because the other switch takes 120 seconds longer to start. To avoid this problem, upgrade the switch running the IP Base license level to the same licensed feature set and software image as the other switch, or manually start the active switch and wait at least 8 seconds before starting the new member switch that is running the IP Base license level.
4. The switch that has the configuration file.
5. The switch with the lowest MAC address.



**Note** The factors for electing or reelecting a new standby switch are same as those for the active switch election or reelection, and are applied to all participating switches except the active switch.

After election, the new active switch becomes available after a few seconds. In the meantime, the switch stack uses the forwarding tables in memory to minimize network disruption. The physical interfaces on the other available stack members are not affected during a new active switch election and reset.

When the previous active switch becomes available, it *does not* resume its role as the active switch.

If you power on or reset an entire switch stack, some stack members *might not* participate in the active switch election. Stack members that are powered on within the same 2-minute timeframe participate in the active switch election and have a chance to become the active switch. Stack members that are powered on after the 120-second timeframe do not participate in this initial election and become stack members. For powering considerations that affect active-switch elections, see the switch hardware installation guide.

As described in the hardware installation guide, you can use the ACTV LED on the switch to see if the switch is the active switch.

A stack master retains its role unless one of these events occurs:

- The switch stack is reset.\*
- The stack master is removed from the switch stack.
- The stack master is reset or powered off.
- The stack master fails.
- The switch stack membership is increased by adding powered-on standalone switches or switch stacks.\*

In the events marked by an asterisk (\*), the current stack master *might* be reelected based on the listed factors.

When you power on or reset an entire switch stack, some stack members *might not* participate in the stack master election. Stack members that are powered on within the same 20-second time frame participate in the stack master election and have a chance to become the stack master. Stack members that are powered on after the 20-second time frame do not participate in this initial election and become stack members. All stack members participate in reelections. For all powering considerations that affect stack-master elections, see the “Switch Installation” chapter in the hardware installation guide.

The new stack master becomes available after a few seconds. In the meantime, the switch stack uses the forwarding tables in memory to minimize network disruption. The physical interfaces on the other available stack members are not affected during a new stack master election and reset.

After a new stack master is elected and the previous stack master becomes available, the previous stack master *does not* resume its role as stack master.

## Switch Stack Configuration Files

The active switch has the saved and running configuration file for the switch stack. The standby switch automatically receives the synchronized running configuration file. Stack members receive synchronized copies when the running configuration file is saved into the startup configuration file. If the active switch becomes unavailable, the standby switch takes over with the current running configuration.

The active switch has the saved and running configuration files for the switch stack. All stack members periodically receive synchronized copies of the configuration files from the active switch. If the active switch becomes unavailable, any stack member assuming the role of active switch has the latest configuration files.

The configuration files record these settings:

- System-level (global) configuration settings such as IP, STP, VLAN, and SNMP settings that apply to all stack members
- Stack member interface-specific configuration settings that are specific for each stack member



---

**Note** The interface-specific settings of the active switch are saved if the active switch is replaced without saving the running configuration to the startup configuration.

---

A new, out-of-box device joining a switch stack uses the system-level settings of that switch stack. If a device is moved to a different switch stack before it is powered on, that device loses its saved configuration file and uses the system-level configuration of the new switch stack. If the device is powered on as a standalone device before it joins the new switch stack, the stack will reload. When the stack reloads, the new device may become the active switch, retain its configuration and overwrite the configuration files of the other stack members.

The interface-specific configuration of each stack member is associated with the stack member number. Stack members retain their numbers unless they are manually changed or they are already used by another member in the same switch stack. If the stack member number changes, the new number goes into effect after that stack member resets.

- If an interface-specific configuration does not exist for that member number, the stack member uses its default interface-specific configuration.
- If an interface-specific configuration exists for that member number, the stack member uses the interface-specific configuration associated with that member number.

If you replace a failed member with an identical model, the replacement member automatically uses the same interface-specific configuration as the failed device. You do not need to reconfigure the interface settings. The replacement device (referred to as the provisioned device) must have the same stack member number as the failed device.

You back up and restore the stack configuration in the same way as you would for a standalone device configuration.

## Offline Configuration to Provision a Stack Member

You can use the offline configuration feature to *provision* (to supply a configuration to) a new switch before it joins the switch stack. You can configure the stack member number, the switch type, and the interfaces associated with a switch that is not currently part of the stack. The configuration that you create on the switch stack is called the *provisioned configuration*. The switch that is added to the switch stack and that receives this configuration is called the *provisioned switch*.

You manually create the provisioned configuration through the **switch stack-member-number provision type** global configuration command. You must change the *stack-member-number* on the provisioned switch before you add it to the stack, and it must match the stack member number that you created for the new switch on the switch stack. The switch type in the provisioned configuration must match the switch type of the newly

added switch. The provisioned configuration is automatically created when a switch is added to a switch stack and when no provisioned configuration exists.

When you configure the interfaces associated with a provisioned switch, the switch stack accepts the configuration, and the information appears in the running configuration. However, as the switch is not active, any configuration on the interface is not operational and the interface associated with the provisioned switch does not appear in the display of the specific feature. For example, VLAN configuration information associated with a provisioned switch does not appear in the **show vlan** user EXEC command output on the switch stack.

The switch stack retains the provisioned configuration in the running configuration whether or not the provisioned switch is part of the stack. You can save the provisioned configuration to the startup configuration file by entering the **copy running-config startup-config** privileged EXEC command. The startup configuration file ensures that the switch stack can reload and can use the saved information whether or not the provisioned switch is part of the switch stack.

## Effects of Adding a Provisioned Switch to a Switch Stack

When you add a provisioned Device to the switch stack, the stack applies either the provisioned configuration or the default configuration. This table lists the events that occur when the switch stack compares the provisioned configuration with the provisioned switch.

**Table 181: Results of Comparing the Provisioned Configuration with the Provisioned Switch**

Scenario	Result
The stack member numbers and the Device types match.	<ol style="list-style-type: none"> <li>1. If the stack member number of the provisioned switch matches the stack member number in the provisioned configuration on the stack, and</li> <li>2. If the Device type of the provisioned switch matches the Device type in the provisioned configuration on the stack.</li> </ol>
The stack member numbers match but the Device types do not match.	<ol style="list-style-type: none"> <li>1. If the stack member number of the provisioned switch matches the stack member number in the provisioned configuration on the stack, but</li> <li>2. The Device type of the provisioned switch does not match the Device type in the provisioned configuration on the stack.</li> </ol>
The stack member number is not found in the provisioned configuration.	<p>The switch stack applies the default configuration to the provisioned switch and adds it to the stack.</p> <p>The provisioned configuration is changed to reflect the new information.</p>

Scenario		Result
The stack member number of the provisioned switch is not found in the provisioned configuration.		The switch stack applies the default configuration to the provisioned switch and adds it to the stack.

If you add a provisioned switch that is a different type than specified in the provisioned configuration to a powered-down switch stack and then apply power, the switch stack rejects the (now incorrect) **switch stack-member-number provision type** global configuration command in the startup configuration file. However, during stack initialization, the nondefault interface configuration information in the startup configuration file for the provisioned interfaces (potentially of the wrong type) is executed. Depending on the differences between the actual Device type and the previously provisioned switch type, some commands are rejected, and some commands are accepted.



**Note** If the switch stack does not contain a provisioned configuration for a new Device, the Device joins the stack with the default interface configuration. The switch stack then adds to its running configuration with a **switch stack-member-number provision type** global configuration command that matches the new Device. For configuration information, see the *Provisioning a New Member for a Switch Stack* section.

## Effects of Replacing a Provisioned Switch in a Switch Stack

When a provisioned switch in a switch stack fails, it is removed from the stack, and is replaced with another Device, the stack applies either the provisioned configuration or the default configuration to it. The events that occur when the switch stack compares the provisioned configuration with the provisioned switch are the same as those when you add a provisioned switch to a stack.

## Effects of Removing a Provisioned Switch from a Switch Stack

If you remove a provisioned switch from the switch stack, the configuration associated with the removed stack member remains in the running configuration as provisioned information. To completely remove the configuration, use the **no switch stack-member-number provision** global configuration command.

## Upgrading a Switch Running Incompatible Software

The auto-upgrade and auto-advise features enable a switch with software packages that are incompatible with the switch stack to be upgraded to a compatible software version so that it can join the switch stack.

### Auto-Upgrade

The purpose of the auto-upgrade feature is to allow a switch to be upgraded to a compatible software image, so that the switch can join the switch stack.

The switch with the higher version of software is made the active switch and all other switches that are to be upgraded are booted simultaneously. If you have new switches to add to the stack, first power them off, add them to the stack and then boot them simultaneously. You cannot add more members to a stack when an auto-upgrade is going on in the stack. You can add new members only after the on-going auto-upgrade process is completed.

When a new switch attempts to join a switch stack, each stack member performs compatibility checks with itself and the new switch. Each stack member sends the results of the compatibility checks to the active switch, which uses the results to determine whether the switch can join the switch stack. If the software on the new switch is incompatible with the switch stack, the new switch enters version-mismatch (VM) mode.

If the auto-upgrade feature is enabled on the existing switch stack, the active switch automatically upgrades the new switch with the same software image running on a compatible stack member. Auto-upgrade starts a few minutes after the mismatched software is detected before starting.

You can perform auto-upgrade on the newly added member of a stack only after the existing members of the stack are already auto-upgraded.

Auto-upgrade is disabled by default.

Note the following limitations before starting an auto-upgrade:

- Do not perform an auto-upgrade in bundle mode.
- Do not perform an auto-upgrade in half-ring stack.
- Do not perform stack merge of two active switches that have different version of images.
- Do not perform staggered boot of the switches to be upgraded.

Auto-upgrade includes an auto-copy process and an auto-extract process.

- Auto-copy automatically copies the software image running on any stack member to the new switch to automatically upgrade it. Auto-copy occurs if auto-upgrade is enabled, if there is enough flash memory in the new switch, and if the software image running on the switch stack is suitable for the new switch.




---

**Note** A switch in VM mode might not run all released software. For example, new switch hardware is not recognized in earlier versions of software.

---

- Automatic extraction (auto-extract) occurs when the auto-upgrade process cannot find the appropriate software in the stack to copy to the new switch. In that case, the auto-extract process searches all switches in the stack for the bin file needed to upgrade the switch stack or the new switch. The bin file can be in any flash file system in the switch stack or in the new switch. If a bin file suitable for the new switch is found on a stack member, the process extracts the file and automatically upgrades the new switch.

The auto-upgrade feature is not available in bundle mode. The switch stack must be running in installed mode. If the switch stack is in bundle mode, use the **software expand** privileged EXEC command to change to installed mode.

You can enable auto-upgrade by using the **software auto-upgrade enable** global configuration command on the new switch. You can check the status of auto-upgrade by using the **show running-config** privileged EXEC command and by checking the *Auto upgrade* line in the display.

You can configure auto-upgrade to upgrade the new switch with a specific software bundle by using the **software auto-upgrade source url** global configuration command. If the software bundle is invalid, the new switch is upgraded with the same software image running on a compatible stack member.

When the auto-upgrade process is complete, the new switch reloads and joins the stack as a fully functioning member. If you have both stack cables connected during the reload, network downtime does not occur because the switch stack operates on two rings.



For more information about upgrading a switch running incompatible software see the *Cisco IOS File System, Configuration Files, and Bundle Files Appendix, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)*.

## Auto-Advise

The auto-advise feature is triggered when:

- The auto-upgrade feature is disabled.
- The new switch is in bundle mode and the stack is in installed mode. Auto-advise displays syslog messages about using the **software auto-upgrade** privileged EXEC command to change the new switch to installed mode.
- The stack is in bundle mode. Auto-advise displays syslog messages about booting the new switch in bundle mode so that it can join the stack.
- An auto-upgrade attempt fails because the new switch is running incompatible software. After the switch stack performs compatibility checks with the new switch, auto-advise displays syslog messages about whether the new switch can be auto-upgraded.

Auto-advise cannot be disabled. It does *not* give suggestions when the switch stack software and the software of the switch in version-mismatch (VM) mode do not contain the same license level.

Automatic advise (auto-advise) occurs when the auto-upgrade process cannot find appropriate stack member software to copy to the new switch. This process tells you the command (**archive copy-sw** or **archive download-sw** privileged EXEC command) and the image name (tar filename) needed to manually upgrade the switch stack or the new switch. The recommended image can be the running switch stack image or a tar file in any flash file system in the switch stack (including the new switch). If an appropriate image is not found in the stack flash file systems, the auto-advise process tells you to install new software on the switch stack. Auto-advise cannot be disabled, and there is no command to check its status.

## Examples of Auto-Advise Messages

### Auto-Upgrade Is Disabled and Incompatible Switch Attempting to Join: Example

This sample auto-advise output shows the system messages displayed when the auto-upgrade feature is disabled and an incompatible switch 1 tries to join the switch stack:

```
*Oct 18 08:36:19.379: %INSTALLER-6-AUTO_ADVISE_SW_INITIATED: 2 installer: Auto advise
initiated for switch 1
*Oct 18 08:36:19.380: %INSTALLER-6-AUTO_ADVISE_SW: 2 installer: Searching stack for software
to upgrade switch 1
*Oct 18 08:36:19.382: %INSTALLER-6-AUTO_ADVISE_SW: 2 installer: Switch 1 with incompatible
software has been
added to the stack. The
software running on
*Oct 18 08:36:19.382: %INSTALLER-6-AUTO_ADVISE_SW: 2 installer: all stack members was
scanned and it has been
*Oct 18 08:36:19.382: %INSTALLER-6-AUTO_ADVISE_SW: 2 installer: determined that the 'software
auto-upgrade'
command can be used to
install compatible
*Oct 18 08:36:19.382: %INSTALLER-6-AUTO_ADVISE_SW: 2 installer: software on switch 1.
```

### Auto-Upgrade is Disabled and New Switch is in Bundle Mode: Example

This sample auto-advise output shows the system messages displayed when auto-upgrade is disabled and a switch running in bundle mode tries to join the stack that is running in installed mode:

```
*Oct 18 11:09:47.005: %INSTALLER-6-AUTO_ADVISE_SW_INITIATED: 2 installer: Auto advise
initiated for switch 1
*Oct 18 11:09:47.005: %INSTALLER-6-AUTO_ADVISE_SW: 2 installer: Switch 1 running bundled
software has been added
*Oct 18 11:09:47.005: %INSTALLER-6-AUTO_ADVISE_SW: 2 installer: to the stack that is running
installed software.
*Oct 18 11:09:47.005: %INSTALLER-6-AUTO_ADVISE_SW: 2 installer: The 'software auto-upgrade'
command can be used to
*Oct 18 11:09:47.005: %INSTALLER-6-AUTO_ADVISE_SW: 2 installer: convert switch 1 to the
installed running mode by
*Oct 18 11:09:47.005: %INSTALLER-6-AUTO_ADVISE_SW: 2 installer: installing its running
software.
```

## Switch Stack Management Connectivity

You manage the switch stack and the stack member interfaces through the active switch. You can use the CLI, SNMP, and supported network management applications such as CiscoWorks. You cannot manage stack members on an individual Device basis.




---

**Note** Use SNMP to manage network features across the stack that are defined by supported MIBs. The switch does not support MIBs to manage stacking-specific features such as stack membership and election.

---

### Connectivity to the Switch Stack Through an IP Address

The switch stack is managed through a single IP address. The IP address is a system-level setting and is not specific to the active switch or to any other stack member. You can still manage the stack through the same IP address even if you remove the active switch or any other stack member from the stack, provided there is IP connectivity.




---

**Note** Stack members retain their IP addresses when you remove them from a switch stack. To avoid a conflict by having two devices with the same IP address in your network, change the IP addresses of any Device that you remove from the switch stack.

---

For related information about switch stack configurations, see the *Switch Stack Configuration Files* section.

### Connectivity to the Switch Stack Through Console Ports or Ethernet Management Ports

You can connect to the active switch by using one of these methods:

- You can connect a terminal or a PC to the active switch through the console port of one or more stack members.
- You can connect a PC to the active switch through the Ethernet management ports of one or more stack members. For more information about connecting to the switch stack through Ethernet management ports, see the *Using the Ethernet Management Port* section.

You can connect to the active switch by connecting a terminal or a PC to the stack master through the console port of one or more stack members.

Be careful when using multiple CLI sessions to the active switch. Commands that you enter in one session are not displayed in the other sessions. Therefore, it is possible that you might not be able to identify the session from which you entered a command.

We recommend using only one CLI session when managing the switch stack.

## How to Configure a Switch Stack

### Enabling the Persistent MAC Address Feature



**Note** When you enter the command to configure this feature, a warning message appears with the consequences of your configuration. You should use this feature cautiously. Using the old active switch MAC address elsewhere in the same domain could result in lost traffic.

Follow these steps to enable persistent MAC address:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>stack-mac persistent timer [0   <i>time-value</i>]</b> <b>Example:</b> Device(config)# <b>stack-mac persistent timer 7</b>	Enables a time delay after a stack-master change before the stack MAC address changes to that of the new active switch. If the previous active switch rejoins the stack during this period, the stack uses that MAC address as the stack MAC address. <p>You can configure the time period as 0 to 60 minutes.</p> <ul style="list-style-type: none"> <li>• Enter the command with no value to set the default delay of approximately 4 minutes. We recommend that you always enter a value.</li> </ul>

	Command or Action	Purpose
		<p>If the command is entered without a value, the time delay appears in the running-config file with an explicit timer value of 4 minutes.</p> <ul style="list-style-type: none"> <li>Enter <b>0</b> to continue using the MAC address of the current active switch indefinitely.</li> </ul> <p>The stack MAC address of the previous active switch is used until you enter the <b>no stack-mac persistent timer</b> command, which immediately changes the stack MAC address to that of the current active switch.</p> <ul style="list-style-type: none"> <li>Enter a <i>time-value</i> from 1 to 60 minutes to configure the time period before the stack MAC address changes to the new active switch.</li> </ul> <p>The stack MAC address of the previous active switch is used until the configured time period expires or until you enter the <b>no stack-mac persistent timer</b> command.</p> <p><b>Note</b> If you enter the <b>no stack-mac persistent timer</b> command after a new active switch takes over, before the time expires, the switch stack moves to the current active switch MAC address.</p>
<b>Step 4</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 5</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

### What to do next

Use the **no stack-mac persistent timer** global configuration command to disable the persistent MAC address feature.

## Assigning a Stack Member Number

This optional task is available only from the active switch.

Follow these steps to assign a member number to a stack member:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>switch</b> <i>current-stack-member-number</i> <b>renumber</b> <i>new-stack-member-number</i> <b>Example:</b> Device# <b>switch 3 renumber 4</b>	Specifies the current stack member number and the new stack member number for the stack member. The range is 1 to 9.  Specifies the current stack member number and the new member number for the stack member. The range is 1 to 2.  You can display the current stack member number by using the <b>show switch</b> user EXEC command.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>reload slot</b> <i>stack-member-number</i> <b>Example:</b> Device# <b>reload slot 4</b>	Resets the stack member.
<b>Step 6</b>	<b>show switch</b> <b>Example:</b> showDevice	Verify the stack member number.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b>	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Device# <code>copy running-config startup-config</code>	

## Setting the Stack Member Priority Value

This optional task is available only from the active switch.

Follow these steps to assign a priority value to a stack member:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device# <code>enable</code>	Enables privileged EXEC mode. Enter your password if prompted.
<b>Step 2</b>	<b>switch</b> <i>stack-member-number</i> <b>priority</b> <i>new-priority-number</i> <b>Example:</b> Device# <code>switch 3 priority 2</code>	Specifies the stack member number and the new priority for the stack member. The stack member number range is 1 to 9. The priority value range is 1 to 15.  You can display the current priority value by using the <b>show switch</b> user EXEC command.  The new priority value takes effect immediately but does not affect the current active switch. The new priority value helps determine which stack member is elected as the new active switch when the current active switch or switch stack resets.
<b>Step 3</b>	<b>show switch</b> <i>stack-member-number</i> <b>Example:</b> Device# <code>show switch</code>	Verify the stack member priority value.
<b>Step 4</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Provisioning a New Member for a Switch Stack

This optional task is available only from the active switch.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>show switch</b> <b>Example:</b> Device# <code>show switch</code>	Displays summary information about the switch stack.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>switch <i>stack-member-number</i> provision <i>type</i></b> <b>Example:</b> Device(config)# <code>switch 3 provision WS-xxxx</code>	Specifies the stack member number for the preconfigured switch. By default, no switches are provisioned.  For <i>stack-member-number</i> , the range is 1 to 9. Specify a stack member number that is not already used in the switch stack. See Step 1.  For <i>type</i> , enter the model number of a supported switch that is listed in the command-line help strings.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Removing Provisioned Switch Information

Before you begin, you must remove the provisioned switch from the stack. This optional task is available only from the active switch.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>no switch <i>stack-member-number</i> provision</b> <b>Example:</b> Device(config)# <b>no switch 3 provision</b>	Removes the provisioning information for the specified member.
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 4</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

### Example

If you are removing a provisioned switch in a stack with this configuration:

- The stack has four members
- Stack member 1 is the active switch
- Stack member 3 is a provisioned switch

and want to remove the provisioned information and to avoid receiving an error message, you can remove power from stack member 3, disconnect the StackWise-480stack cables between the stack member 3 and switches to which it is connected, reconnect the cables between the remaining stack members, and enter the **no switch *stack-member-number* provision** global configuration command.

## Displaying Incompatible Switches in the Switch Stack

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>show switch</b> <b>Example:</b> Device# <b>show switch</b>	Displays any incompatible switches in the switch stack (indicated by a 'Current State' of 'V-Mismatch'). The V-Mismatch state identifies the switches with incompatible software. The output displays Lic-Mismatch for switches that are not running the same license level as the active switch.  For information about managing license levels, see the <i>System Management Configuration Guide (Catalyst 3850 Switches)</i> .



## Upgrading an Incompatible Switch in the Switch Stack

### Before you begin

- Ensure the switches are install booted.
- Ensure that the stack is connected in full ring mode.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>software auto-upgrade</b> <b>Example:</b> Device# <code>software auto-upgrade</code>	Upgrades incompatible switches in the switch stack, or changes switches in bundle mode to installed mode.
<b>Step 2</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

## Troubleshooting the Switch Stack

### Temporarily Disabling a Stack Port

If a stack port is flapping and causing instability in the stack ring, to disable the port, enter the **switch stack-member-number stack port port-number disable** privileged EXEC command. To reenable the port, enter the **switch stack-member-number stack port port-number enable** command.



**Note** Be careful when using the **switch stack-member-number stack port port-number disable** command. When you disable the stack port, the stack operates at half bandwidth.

A stack is in the full-ring state when all members are connected through the stack ports and are in the ready state.

The stack is in the partial-ring state when the following occurs:

- All members are connected through their stack ports but some are not in the ready state.
- Some members are not connected through the stack ports.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>switch</b> <i>stack-member-number</i> <b>stack port</b> <i>port-number</i> <b>disable</b>  <b>Example:</b> Device# <b>switch 2 stack port 1 disable</b>	Disables the specified stack port.
<b>Step 2</b>	<b>switch</b> <i>stack-member-number</i> <b>stack port</b> <i>port-number</i> <b>enable</b>  <b>Example:</b> Device# <b>switch 2 stack port 1 enable</b>	Reenables the stack port.

When you disable a stack port and the stack is in the full-ring state, you can disable only one stack port. This message appears:

```
Enabling/disabling a stack port may cause undesired stack changes. Continue?[confirm]
```

When you disable a stack port and the stack is in the partial-ring state, you cannot disable the port. This message appears:

```
Disabling stack port not allowed with current stack configuration.
```

## Reenabling a Stack Port While Another Member Starts

Stack Port 1 on Switch 1 is connected to Port 2 on Switch 4. If Port 1 is flapping, you can disable Port 1 with the **switch 1 stack port 1 disable** privileged EXEC command. While Port 1 on Switch 1 is disabled and Switch 1 is still powered on, follow these steps to reenabling a stack port:

**Procedure**

- 
- Step 1** Disconnect the stack cable between Port 1 on Switch 1 and Port 2 on Switch 4.
  - Step 2** Remove Switch 4 from the stack.
  - Step 3** Add a switch to replace Switch 4 and assign it switch-number 4.
  - Step 4** Reconnect the cable between Port 1 on Switch 1 and Port 2 on Switch 4 (the replacement switch).
  - Step 5** Reenable the link between the switches. Enter the **switch 1 stack port 1 enable** privileged EXEC command to enable Port 1 on Switch 1.
  - Step 6** Power on Switch 4.
- 



**Caution** Powering on Switch 4 before enabling the Port 1 on Switch 1 might cause one of the switches to reload.

If Switch 4 is powered on first, you might need to enter the **switch 1 stack port 1 enable** and the **switch 4 stack port 2 enable** privileged EXEC commands to bring up the link.

---

# Monitoring the Device Stack

Table 182: Commands for Displaying Stack Information

Command	Description
<b>show switch</b>	Displays summary information about the stack, including the status of provisioned switches and switches in version-mismatch mode.
<b>show switch</b> <i>stack-member-number</i>	Displays information about a specific member.
<b>show switch detail</b>	Displays detailed information about the stack.
<b>show switch neighbors</b>	Displays the stack neighbors.
<b>show switch stack-ports</b> [summary]	Displays port information for the stack. Use the <b>summary</b> keyword to display the stack cable length, the stack link status, and the loopback status.
<b>show redundancy</b>	Displays the redundant system and the current processor information. The redundant system information includes the system uptime, standby failures, switchover reason, hardware, configured and operating redundancy mode. The current processor information displayed includes the active location, the software state, the uptime in the current state and so on.
<b>show redundancy state</b>	Displays all the redundancy states of the active and standby devices.

## Configuration Examples for Switch Stacks

### Switch Stack Configuration Scenarios

Most of these switch stack configuration scenarios assume that at least two device are connected through their StackWise-480stack ports.

Table 183: Configuration Scenarios

Scenario	Result
Active switch election specifically determined by existing active switches	Connect two powered-on switch stacks through the StackWise-480stack ports. Only one of the two active switches becomes the new active switch.

Scenario		Result
Active switch election specifically determined by the stack member priority value	<ol style="list-style-type: none"> <li>1. Connect two switches through their StackWise-480stack ports.</li> <li>2. Use the <b>switch stack-member-number priority new-priority-number</b> global configurationEXEC command to set one stack member with a higher member priority value.</li> <li>3. Restart both stack members at the same time.</li> </ol>	The stack member with the higher priority value is elected active switch.
Active switch election specifically determined by the configuration file	<p>Assuming that both stack members have the same priority value:</p> <ol style="list-style-type: none"> <li>1. Make sure that one stack member has a default configuration and that the other stack member has a saved (nondefault) configuration file.</li> <li>2. Restart both stack members at the same time.</li> </ol>	The stack member with the saved configuration file is elected active switch.
Active switch election specifically determined by the MAC address	<p>Assuming that both stack members have the same priority value, configuration file, and feature setlicense level, restart both stack members at the same time.</p>	The stack member with the lower MAC address is elected active switch.
Stack member number conflict	<p>Assuming that one stack member has a higher priority value than the other stack member:</p> <ol style="list-style-type: none"> <li>1. Ensure that both stack members have the same stack member number. If necessary, use the <b>switch current-stack-member-number renumber new-stack-member-number</b> global configurationEXEC command.</li> <li>2. Restart both stack members at the same time.</li> </ol>	The stack member with the higher priority value retains its stack member number. The other stack member has a new stack member number.
Add a stack member	<ol style="list-style-type: none"> <li>1. Power off the new switch.</li> <li>2. Through their StackWise-480stack ports, connect the new switch to a powered-on switch stack.</li> <li>3. Power on the new switch.</li> </ol>	The active switch is retained. The new switch is added to the switch stack.

Scenario		Result
Active switch failure	Remove (or power off) the active switch.	The standby switch becomes the new active switch. All other stack members in the stack remain as stack members and do not reboot.
Add more than nine stack members	<ol style="list-style-type: none"> <li>Through their StackWise-480stack ports, connect ten device.</li> <li>Power on all device.</li> </ol>	<p>Two device become active switches. One active switch has nine stack members. The other active switch remains as a standalone device.</p> <p>Use the Mode button and port LEDs on the device to identify which device are active switches and which device belong to each active switch.</p>

## Enabling the Persistent MAC Address Feature: Example

This example shows how to configure the persistent MAC address feature for a 7-minute time delay and to verify the configuration:

```
Device(config)# stack-mac persistent timer 7
WARNING: The stack continues to use the base MAC of the old Master
WARNING: as the stack MAC after a master switchover until the MAC
WARNING: persistency timer expires. During this time the Network
WARNING: Administrators must make sure that the old stack-mac does
WARNING: not appear elsewhere in this network domain. If it does,
WARNING: user traffic may be blackholed.
Device(config)# end
Device# show switch
Switch/Stack Mac Address : 0016.4727.a900
Mac persistency wait time: 7 mins

Switch# Role Mac Address Priority Version State
-----
*1 Active 0016.4727.a900 1 P2B Ready
```

## Provisioning a New Member for a Switch Stack: Example

This example shows how to provision a switch with a stack member number of 2 for the switch stack. The **show running-config** command output shows the interfaces associated with the provisioned switch:

```
Device(config)# switch 2 provision switch_PID
Device(config)# end
Device# show running-config | include switch 2
!
interface GigabitEthernet2/0/1
!
interface GigabitEthernet2/0/2
!
interface GigabitEthernet2/0/3
<output truncated>
```

## show switch stack-ports summary Command Output: Example

Only Port 1 on stack member 2 is disabled.

```
Device# show switch stack-ports summary
Device#/ Stack Neighbor Cable Link Link Sync # In
Port# Port Status Length OK Active OK Changes Loopback
To LinkOK
-----
1/1 OK 3 50 cm Yes Yes Yes 1 No
1/2 Down None 3 m Yes No Yes 1 No
2/1 Down None 3 m Yes No Yes 1 No
2/2 OK 3 50 cm Yes Yes Yes 1 No
3/1 OK 2 50 cm Yes Yes Yes 1 No
3/2 OK 1 50 cm Yes Yes Yes 1 No
```

**Table 184: show switch stack-ports summary Command Output**

Field	Description
Switch#/Port#	Member number and its stack port number.
Stack Port Status	Status of the stack port. <ul style="list-style-type: none"> <li>Absent—No cable is detected on the stack port.</li> <li>Down—A cable is detected, but either no connected neighbor is up, or the stack port is disabled.</li> <li>OK—A cable is detected, and the connected neighbor is up.</li> </ul>
Neighbor	Switch number of the active member at the other end of the stack cable.
Cable Length	Valid lengths are 50 cm, 1 m, or 3 m. If the switch cannot detect the cable length, the value is <i>no cable</i> . The cable might not be connected, or the link might be unreliable.
Link OK	Whether the stack cable is connected and functional. There may or may not be a neighbor connected on the other end. The <i>link partner</i> is a stack port on a neighbor switch. <ul style="list-style-type: none"> <li>No—There is no stack cable connected to this port or the stack cable is not functional.</li> <li>Yes—There is a functional stack cable connected to this port.</li> </ul>
Link Active	Whether a neighbor is connected on the other end of the stack cable. <ul style="list-style-type: none"> <li>No—No neighbor is detected on the other end. The port cannot send traffic over this link.</li> <li>Yes—A neighbor is detected on the other end. The port can send traffic over this link.</li> </ul>

Field	Description
Sync OK	Whether the link partner sends valid protocol messages to the stack port. <ul style="list-style-type: none"> <li>• No—The link partner does not send valid protocol messages to the stack port.</li> <li>• Yes—The link partner sends valid protocol messages to the port.</li> </ul>
# Changes to LinkOK	The relative stability of the link. If a large number of changes occur in a short period of time, link flapping can occur.
In Loopback	Whether a stack cable is attached to a stack port on the member. <ul style="list-style-type: none"> <li>• No—At least one stack port on the member has an attached stack cable.</li> <li>• Yes—None of the stack ports on the member has an attached stack cable.</li> </ul>

## Software Loopback: Examples

In a stack with three members, stack cables connect all the members:

```
Device# show switch stack-ports summary
Device#
Sw#/Port#  Port      Neighbor  Cable   Link   Link   Sync   #Changes   In
            Status                Length  OK     Active OK     To LinkOK Loopback
-----
1/1        OK         3         50 cm   Yes    Yes    Yes    1          No
1/2        OK         2         3 m     Yes    Yes    Yes    1          No
2/1        OK         1         3 m     Yes    Yes    Yes    1          No
2/2        OK         3         50 cm   Yes    Yes    Yes    1          No
3/1        OK         2         50 cm   Yes    Yes    Yes    1          No
3/2        OK         1         50 cm   Yes    Yes    Yes    1          No
```

If you disconnect the stack cable from Port 1 on Switch 1, these messages appear:

```
01:09:55: %STACKMGR-4-STACK_LINK_CHANGE: Stack Port 2 Switch 3 has changed to state DOWN
01:09:56: %STACKMGR-4-STACK_LINK_CHANGE: Stack Port 1 Switch 1 has changed to state DOWN
```

```
Device# show switch stack-ports summary
Device#
Sw#/Port#  Port      Neighbor  Cable   Link   Link   Sync   #Changes   In
            Status                Length  OK     Active OK     To LinkOK Loopback
-----
1/1        Absent    None      No cable No     No     No     1          No
1/2        OK         2         3 m     Yes    Yes    Yes    1          No
2/1        OK         1         3 m     Yes    Yes    Yes    1          No
2/2        OK         3         50 cm   Yes    Yes    Yes    1          No
3/1        OK         2         50 cm   Yes    Yes    Yes    1          No
3/2        Down      None      50 cm   No     No     No     1          No
```

If you disconnect the stack cable from Port 2 on Switch 1, the stack splits.

Switch 2 and Switch 3 are now in a two-member stack connected through stack cables:

```
Device# show sw stack-ports summary
Device#
Sw#/Port#  Port      Neighbor  Cable   Link  Link  Sync  #Changes  In
           Status                    Length  OK    Active OK    To LinkOK Loopback
-----
2/1        Down      None      3 m     No    No    No    1          No
2/2        OK        3         50 cm   Yes   Yes   Yes   1          No
3/1        OK        2         50 cm   Yes   Yes   Yes   1          No
3/2        Down      None      50 cm   No    No    No    1          No
```

Switch 1 is a standalone switch:

```
Device# show switch stack-ports summary
Device#
Sw#/Port#  Port      Neighbor  Cable   Link  Link  Sync  #Changes  In
           Status                    Length  OK    Active OK    To LinkOK Loopback
-----
1/1        Absent    None      No cable No    No    No    1          Yes
1/2        Absent    None      No cable No    No    No    1          Yes
```

## Software Loopback with Connected Stack Cables: Examples

- On Port 1 on Switch 1, the port status is *Down*, and a cable is connected.

On Port 2 on Switch 1, the port status is *Absent*, and no cable is connected.

```
Device# show switch stack-ports summary
Device#
Sw#/Port#  Port      Neighbor  Cable   Link  Link  Sync  #Changes  In
           Status                    Length  OK    Active OK    To LinkOK Loopback
-----
1/1        Down      None      50 Cm   No    No    No    1          No
1/2        Absent    None      No cable No    No    No    1          No
```

- In a *physical loopback*, a cable connects both stack ports on a switch. You can use this configuration to test
  - Cables on a switch that is running properly
  - Stack ports with a cable that works properly

```
Device# show switch stack-ports summary
Device#
Sw#/Port#  Port      Neighbor  Cable   Link  Link  Sync  #Changes  In
           Status                    Length  OK    Active OK    To LinkOK Loopback
-----
2/1        OK        2         50 cm   Yes   Yes   Yes   1          No
2/2        OK        2         50 cm   Yes   Yes   Yes   1          No
```

The port status shows that

- Switch 2 is a standalone switch.
- The ports can send and receive traffic.



## Software Loopback with no Connected Stack Cable: Example

```
Device# show switch stack-ports summary
Device#
Sw#/Port#  Port      Neighbor  Cable   Link  Link  Sync  #Changes  In
           Status                Length  OK    Active OK    To LinkOK Loopback
-----
1/1        Absent    None      No cable No    No    No    1         Yes
1/2        Absent    None      No cable No    No    No    1         Yes
```

## Finding a Disconnected Stack Cable: Example

Stack cables connect all stack members. Port 2 on Switch 1 connects to Port 1 on Switch 2.

This is the port status for the members:

```
Device# show switch stack-ports summary
Device#
Sw#/Port#  Port      Neighbor  Cable   Link  Link  Sync  #Changes  In
           Status                Length  OK    Active OK    To LinkOK Loopback
-----
1/1        OK        2         50 cm   Yes   Yes   Yes   0         No
1/2        OK        2         50 cm   Yes   Yes   Yes   0         No
2/1        OK        1         50 cm   Yes   Yes   Yes   0         No
2/2        OK        1         50 cm   Yes   Yes   Yes   0         No
```

If you disconnect the cable from Port 2 on Switch 1, these messages appear:

```
%STACKMGR-4-STACK_LINK_CHANGE: Stack Port 1 Switch 2 has changed to state DOWN
%STACKMGR-4-STACK_LINK_CHANGE: Stack Port 2 Switch 1 has changed to state DOWN
```

This is now the port status:

```
Device# show switch stack-ports summary
Device#
Sw#/Port#  Port      Neighbor  Cable   Link  Link  Sync  #Changes  In
           Status                Length  OK    Active OK    To LinkOK Loopback
-----
1/1        OK        2         50 cm   Yes   Yes   Yes   1         No
1/2        Absent    None      No cable No    No    No    2         No
2/1        Down     None      50 cm   No    No    No    2         No
2/2        OK        1         50 cm   Yes   Yes   Yes   1         No
```

Only one end of the cable connects to a stack port, Port 1 on Switch 2.

- The *Stack Port Status* value for Port 2 on Switch 1 is *Absent*, and the value for Port 1 on Switch 2 is *Down*.
- The *Cable Length* value is *No cable*.

Diagnosing the problem:

- Verify the cable connection for Port 2 on Switch 1.

- Port 2 on Switch 1 has a port or cable problem if
  - The *In Loopback* value is *Yes*.

or

- The *Link OK*, *Link Active*, or *Sync OK* value is *No*.

## Fixing a Bad Connection Between Stack Ports: Example

Stack cables connect all members. Port 2 on Switch 1 connects to Port 1 on Switch 2.

This is the port status:

```
Device# show switch stack-ports summary
Device#
Sw#/Port#  Port      Neighbor  Cable   Link   Link   Sync   #Changes  In
           Status                    Length  OK     Active OK     To LinkOK Loopback
-----
1/1        OK        2         50 cm   Yes    Yes    Yes    1         No
1/2        Down     None     50 cm   No     No     No     2         No
2/1        Down     None     50 cm   No     No     No     2         No
2/2        OK        1         50 cm   Yes    Yes    Yes    1         No
```

Diagnosing the problem:

- The Stack Port Status value is *Down*.
- Link OK, Link Active, and Sync OK values are *No*.
- The Cable Length value is *50 cm*. The switch detects and correctly identifies the cable.

The connection between Port 2 on Switch 1 and Port 1 on Switch 2 is unreliable on at least one of the connector pins.

## Additional References for Switch Stacks

### Related Documents

Related Topic	Document Title
Cabling and powering on a switch stack.	<i>Catalyst 3850 Switch Hardware Installation Guide</i>
SGACL High Availability	" <a href="#">Cisco TrustSec SGACL High Availability</a> " module of the <i>Cisco TrustSec Switch Configuration Guide</i>

**Error Message Decoder**

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**Standards and RFCs**

Standard/RFC	Title
None	—

**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and licensed feature sets,, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>





## CHAPTER 124

# Configuring Cisco NSF with SSO

- [Finding Feature Information, on page 2319](#)
- [Prerequisites for NSF with SSO, on page 2319](#)
- [Restrictions for NSF with SSO, on page 2320](#)
- [Information About NSF with SSO, on page 2320](#)
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## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for NSF with SSO

The following are prerequisites and considerations for configuring NSF with SSO.

- Use of the routing protocols requires the IP Services license level. EIGRP-stub and OSPF for routed access are supported on IP Base license level.
- BGP support in NSF requires that neighbor networking devices be NSF-aware; that is, the devices must have the graceful restart capability and advertise that capability in their OPEN message during session establishment. If an NSF-capable router discovers that a particular BGP neighbor does not have graceful restart capability, it does not establish an NSF-capable session with that neighbor. All other neighbors that have graceful restart capability continue to have NSF-capable sessions with this NSF-capable networking device.
- OSPF support in NSF requires that all neighbor networking devices be NSF-aware. If an NSF-capable router discovers that it has non-NSF -aware neighbors on a particular network segment, it disables NSF capabilities for that segment. Other network segments composed entirely of NSF-capable or NSF-aware routers continue to provide NSF capabilities.

## Restrictions for NSF with SSO

The following are restrictions for configuring NSF with SSO:

- NSF capability is supported for IPv4 routing protocols only. NSF capability is not supported for IPv6 routing protocols.
- NSF does not support IP Multicast Routing, as it is not SSO-aware.
- NSF is not supported if the IOS-XE software is running in the LAN Base mode.
- For NSF operation, you must have SSO configured on the device.
- NSF with SSO supports IP Version 4 traffic and protocols only; NSF with SSO does not support IPv6 traffic.
- All Layer 3 neighboring devices must be NSF Helper or NSF-capable to support graceful restart capability.
- For IETF, all neighboring devices must be running an NSF-aware software image.

## Information About NSF with SSO

### Overview of NSF with SSO

The switch supports fault resistance by allowing a standby switch to take over if the active switch becomes unavailable. Cisco nonstop forwarding (NSF) works with stateful switchover (SSO) to minimize the amount of time a network is unavailable.

NSF provides these benefits:

- Improved network availability—NSF continues forwarding network traffic and application state information so that user session information is maintained after a switchover.
- Overall network stability—Network stability may be improved with the reduction in the number of route flaps, which were created when routers in the network failed and lost their routing tables.
- Neighboring routers do not detect a link flap—Because the interfaces remain up during a switchover, neighboring routers do not detect a link flap (the link does not go down and come back up).
- Prevents routing flaps—Because SSO continues forwarding network traffic during a switchover, routing flaps are avoided.
- Maintains user sessions established prior to the switchover.

Keepalive messages are sent and received between the active and standby switches.

- If the standby switch does not respond, a new standby switch is elected.
- If the active switch does not respond, the standby switch becomes the active switch.

In addition, hello messages are sent and received by all stack members.

- If a stack member does not respond, that member is removed from the stack.

- If the standby switch does not respond, a new standby switch is elected.
- If the active switch does not respond, the standby switch becomes the active switch.

## SSO Operation

When a standby switch runs in SSO mode, the standby switch starts up in a fully-initialized state and synchronizes with the persistent configuration and the running configuration of the active switch. It subsequently maintains the state on the protocols listed below, and all changes in hardware and software states for features that support stateful switchover are kept in synchronization. Consequently, it offers minimum interruption to Layer 2 sessions in a redundant active switch configuration.

If the active switch fails, the standby switch becomes the active switch. This new active switch uses existing Layer 2 switching information to continue forwarding traffic. Layer 3 forwarding will be delayed until the routing tables have been repopulated in the newly active switch.



---

**Note** SSO Layer 2 Only is supported if the IOS-XE software is running the LAN Base license level.

---

The state of these features is preserved between both the active and standby switches:

- 802.3
- 802.3u
- 802.3x (Flow Control)
- 802.3ab (GE)
- 802.3z (Gigabit Ethernet including CWDM)
- 802.3ad (LACP)
- 802.1p (Layer 2 QoS)
- 802.1q
- 802.1X (Authentication)
- 802.1D (Spanning Tree Protocol)
- 802.3af (Inline power)
- PAgP
- VTP
- Dynamic ARP Inspection
- DHCP
- DHCP snooping
- IP source guard
- IGMP snooping (versions 1 and 2)

- DTP (802.1q and ISL)
- MST
- PVST+
- Rapid-PVST
- PortFast/UplinkFast/BackboneFast
- BPDU guard and filtering
- Voice VLAN
- Port security
- Unicast MAC filtering
- ACL (VACLs, PACLS, RACLs)
- QOS (DBL)
- Multicast storm control/broadcast storm control

SSO is compatible with the following list of features. However, the protocol database for these features is not synchronized between the standby and active switches:

- 802.1Q tunneling with Layer 2 Protocol Tunneling (L2PT)
- Baby giants
- Jumbo frame support
- CDP
- Flood blocking
- UDLD
- SPAN/RSPAN
- NetFlow

All Layer 3 protocols on a switch are learned on the standby switch if SSO is enabled.

## NSF Operation

Cisco IOS Nonstop Forwarding (NSF) always runs with stateful switchover (SSO) and provides redundancy for Layer 3 traffic. NSF is supported by the BGP, OSPF, and EIGRP routing protocols and is supported by Cisco Express Forwarding (CEF) for forwarding. The routing protocols have been enhanced with NSF-capability and awareness, which means that routers running these protocols can detect a switchover and take the necessary actions to continue forwarding network traffic and to recover route information from the peer devices.

Each protocol depends on CEF to continue forwarding packets during switchover while the routing protocols rebuild the Routing Information Base (RIB) tables. After the routing protocols have converged, CEF updates the FIB table and removes stale route entries. CEF then updates the hardware with the new FIB information.

If the active switch is configured for BGP (with the **graceful-restart** command), OSPF, or EIGRP routing protocols, routing updates are automatically sent during the active switch election.



The switch supports NSF-awareness and NSF-capability for the BGP, OSPF, and EIGRP protocols in IP Services license level and NSF-awareness for the EIGRP-stub in IP Base license level.

NSF has two primary components:

- NSF-awareness

A networking device is NSF-aware if it is running NSF-compatible software. If neighboring router devices detect that an NSF router can still forward packets when an active switch election happens, this capability is referred to as NSF-awareness. Cisco IOS enhancements to the Layer 3 routing protocols (BGP, OSPF, and EIGRP) are designed to prevent route-flapping so that the CEF routing table does not time out or the NSF router does not drop routes. An NSF-aware router helps to send routing protocol information to the neighboring NSF router. NSF-awareness is enabled by default for EIGRP-stub, EIGRP, and OSPF protocols. NSF-awareness is disabled by default for BGP.

- NSF-capability

A device is NSF-capable if it has been configured to support NSF; it rebuilds routing information from NSF-aware or NSF-capable neighbors. NSF works with SSO to minimize the amount of time that a Layer 3 network is unavailable following an active switch election by continuing to forward IP packets. Reconvergence of Layer 3 routing protocols (BGP, OSPFv2, and EIGRP) is transparent to the user and happens automatically in the background. The routing protocols recover routing information from neighbor devices and rebuild the Cisco Express Forwarding (CEF) table.

## Cisco Express Forwarding

A key element of Cisco IOS Nonstop Forwarding (NSF) is packet forwarding. In a Cisco networking device, packet forwarding is provided by Cisco Express Forwarding (CEF). CEF maintains the FIB and uses the FIB information that was current at the time of the switchover to continue forwarding packets during a switchover. This feature reduces traffic interruption during the switchover.

During normal NSF operation, CEF on the active supervisor switch synchronizes its current FIB and adjacency databases with the FIB and adjacency databases on the standby switch. Upon switchover, the standby switch initially has FIB and adjacency databases that are mirror images of those that were current on the active switch. CEF keeps the forwarding engine on the standby switch current with changes that are sent to it by CEF on the active switch. The forwarding engine can continue forwarding after a switchover as soon as the interfaces and a data path are available.

As the routing protocols start to repopulate the RIB on a prefix-by-prefix basis, the updates cause prefix-by-prefix updates to CEF, which it uses to update the FIB and adjacency databases. Existing and new entries receive the new version (“epoch”) number, indicating that they have been refreshed. The forwarding information is updated on the forwarding engine during convergence. The switch signals when the RIB has converged. The software removes all FIB and adjacency entries that have an epoch older than the current switchover epoch. The FIB now represents the newest routing protocol forwarding information.

## BGP Operation

When an NSF-capable router begins a BGP session with a BGP peer, it sends an OPEN message to the peer. Included in the message is a statement that the NSF-capable device has “graceful” restart capability. Graceful restart is the mechanism by which BGP routing peers avoid a routing flap following a switchover. If the BGP peer has received this capability, it is aware that the device sending the message is NSF-capable. Both the NSF-capable router and its BGP peers need to exchange the graceful restart capability in their OPEN messages

at the time of session establishment. If both the peers do not exchange the graceful restart capability, the session will not be capable of a graceful restart.

If the BGP session is lost during the active switch switchover, the NSF-aware BGP peer marks all the routes associated with the NSF-capable router as stale; however, it continues to use these routes to make forwarding decisions for a set period of time. This functionality prevents packets from being lost while the newly active switch is waiting for convergence of the routing information with the BGP peers.

After an active switch switchover occurs, the NSF-capable router reestablishes the session with the BGP peer. In establishing the new session, it sends a new graceful restart message that identifies the NSF-capable router as having restarted.

At this point, the routing information is exchanged between the two BGP peers. After this exchange is complete, the NSF-capable device uses the routing information to update the RIB and the FIB with the new forwarding information. The NSF-aware device uses the network information to remove stale routes from its BGP table; the BGP protocol then is fully converged.

If a BGP peer does not support the graceful restart capability, it ignores the graceful restart capability in an OPEN message but establishes a BGP session with the NSF-capable device. This function allows interoperability with non-NSF-aware BGP peers (and without NSF functionality), but the BGP session with non-NSF-aware BGP peers is not capable of a graceful restart.

**Note**

BGP support in NSF requires that neighbor networking devices be NSF-aware; that is, the devices must have the graceful restart capability and advertise that capability in their OPEN message during session establishment. If an NSF-capable router discovers that a particular BGP neighbor does not have graceful restart capability, it does not establish an NSF-capable session with that neighbor. All other neighbors that have graceful restart capability continue to have NSF-capable sessions with this NSF-capable networking device.

## OSPF Operation

When an OSPF NSF-capable router performs an active switch switchover, it must perform the following tasks in order to resynchronize its link state database with its OSPF neighbors:

- Relearn the available OSPF neighbors on the network without causing a reset of the neighbor relationship
- Reacquire the contents of the link state database for the network

As quickly as possible after an active switch switchover, the NSF-capable router sends an OSPF NSF signal to neighboring NSF-aware devices. Neighbor networking devices recognize this signal as an indicator that the neighbor relationship with this router should not be reset. As the NSF-capable router receives signals from other routers on the network, it can begin to rebuild its neighbor list.

After neighbor relationships are reestablished, the NSF-capable router begins to resynchronize its database with all of its NSF-aware neighbors. At this point, the routing information is exchanged between the OSPF neighbors. Once this exchange is complete, the NSF-capable device uses the routing information to remove stale routes, update the RIB, and update the FIB with the new forwarding information. The OSPF protocols are then fully converged.



---

**Note** OSPF support in NSF requires that all neighbor networking devices be NSF-aware. If an NSF-capable router discovers that it has non-NSF-aware neighbors on a particular network segment, it disables NSF capabilities for that segment. Other network segments composed entirely of NSF-capable or NSF-aware routers continue to provide NSF capabilities.

---

## EIGRP Operation

When an EIGRP NSF-capable router initially re-boots after an NSF restart, it has no neighbor and its topology table is empty. The router is notified by the standby (now active) switch when it needs to bring up the interfaces, reacquire neighbors, and rebuild the topology and routing tables. The restarting router and its peers must accomplish these tasks without interrupting the data traffic directed toward the restarting router. EIGRP peer routers maintain the routes learned from the restarting router and continue forwarding traffic through the NSF restart process.

To prevent an adjacency reset by the neighbors, the restarting router uses a new Restart (RS) bit in the EIGRP packet header to indicate a restart. The RS bit is set in the hello packets and in the initial INIT update packets during the NSF restart period. The RS bit in the hello packets allows the neighbors to be quickly notified of the NSF restart. Without seeing the RS bit, the neighbor can only detect an adjacency reset by receiving an INIT update or by the expiration of the hello hold timer. Without the RS bit, a neighbor does not know if the adjacency reset should be handled using NSF or the normal startup method.

When the neighbor receives the restart indication, either by receiving the hello packet or the INIT packet, it recognizes the restarting peer in its peer list and maintains the adjacency with the restarting router. The neighbor then sends its topology table to the restarting router with the RS bit set in the first update packet indicating that it is NSF-aware and is helping out the restarting router. The neighbor does not set the RS bit in their hello packets, unless it is also a NSF restarting neighbor.



---

**Note** A router may be NSF-aware but may not be helping the NSF restarting neighbor because booting from a cold start.

---

If at least one of the peer routers is NSF-aware, the restarting router would then receive updates and rebuild its database. The restarting router must then find out if it had converged so that it can notify the routing information base (RIB). Each NSF-aware router is required to send an end of table (EOT) marker in the last update packet to indicate the end of the table content. The restarting router knows it has converged when it receives the EOT marker. The restarting router can then begin sending updates.

An NSF-aware peer would know when the restarting router had converged when it receives an EOT indication from the restarting router. The peer then scans its topology table to search for the routes with the restarted neighbor as the source. The peer compares the route timestamp with the restart event timestamp to determine if the route is still available. The peer then goes active to find alternate paths for the routes that are no longer available through the restarted router.

When the restarting router has received all EOT indications from its neighbors or when the NSF converge timer expires, EIGRP notifies the RIB of convergence. EIGRP waits for the RIB convergence signal and then floods its topology table to all awaiting NSF-aware peers.

# How to Configure Cisco NSF with SSO

## Configuring SSO

You must configure SSO in order to use NSF with any supported protocol.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>redundancy</b> <b>Example:</b> Device(config)# <b>redundancy</b>	Enters redundancy configuration mode.
<b>Step 2</b>	<b>mode sso</b> <b>Example:</b> Device(config-red)# <b>mode sso</b>	Configures SSO. When this command is entered, the standby switch is reloaded and begins to work in SSO mode.
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config-red)# <b>end</b>	Returns to EXEC mode.
<b>Step 4</b>	<b>show running-config</b> <b>Example:</b> Device# <b>show running-config</b>	Verifies that SSO is enabled.
<b>Step 5</b>	<b>show redundancy states</b> <b>Example:</b> Device# <b>show redundancy states</b>	Displays the operating redundancy mode.

## Configuring SSO Example

This example shows how to configure the system for SSO and display the redundancy state:

```
Device(config)# redundancy
Device(config)# mode sso
Device(config)# end
Device# show redundancy states
my state = 13 -ACTIVE
peer state = 8 -STANDBY HOT
Mode = Duplex
Unit = Primary
Unit ID = 5
Redundancy Mode (Operational) = sso
Redundancy Mode (Configured) = sso
Split Mode = Disabled
Manual Swact = Enabled
Communications = Up
client count = 29
```

```

client_notification_TMR = 30000 milliseconds
keep_alive TMR = 9000 milliseconds
keep_alive count = 1
keep_alive threshold = 18
RF debug mask = 0x0

```

## Verifying CEF NSF

To verify CEF NSF, use the **show cef state** privileged EXEC command.

```

Device# show cef state
CEF Status:
RP instance
common CEF enabled
IPv4 CEF Status:
CEF enabled/running
dCEF enabled/running
CEF switching enabled/running
universal per-destination load sharing algorithm, id DEA83012
IPv6 CEF Status:
CEF disabled/not running
dCEF disabled/not running
universal per-destination load sharing algorithm, id DEA83012
RRP state:
I am standby RRP: no
RF Peer Presence: yes
RF PeerComm reached: yes
RF Progression blocked: never
Redundancy mode: rpr(1)
CEF NSF sync: disabled/not running
CEF ISSU Status:
FIBHWIDB broker
No slots are ISSU capable.
FIBIDB broker
No slots are ISSU capable.
FIBHWIDB Subblock broker
No slots are ISSU capable.
FIBIDB Subblock broker
No slots are ISSU capable.
Adjacency update
No slots are ISSU capable.
IPv4 table broker
No slots are ISSU capable.
CEF push
No slots are ISSU capable.

```

## Configuring BGP for NSF

You must configure BGP graceful restart on all peer devices participating in BGP NSF.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device(config)# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>router bgp as-number</b> <b>Example:</b> Device(config)# <b>router bgp 300</b>	Enables a BGP routing process, which places the switch in switch configuration mode.
<b>Step 3</b>	<b>bgp graceful-restart</b> <b>Example:</b> Device(config)# <b>bgp graceful-restart</b>	Enables the BGP graceful restart capability, starting BGP NSF. If you enter this command after the BGP session has been established, you must restart the session for the capability to be exchanged with the BGP neighbor. Use this command on the restarting switch and all of its peers.

## Verifying BGP NSF

To verify BGP NSF, you must check that BGP graceful restart is configured on the SSO-enabled networking device and on the neighbor devices. To verify, follow these steps:

### Procedure

- 
- Step 1** Verify that “bgp graceful-restart” appears in the BGP configuration of the SSO-enabled switch by entering the **show running-config** command:
- Example:**
- ```
Device# show running-config
.
.
.
router bgp 120
.
.
.
bgp graceful-restart
neighbor 192.0.2.0 remote-as 300
.
.
.
```
- Step 2** Repeat Step 1 on each of the BGP neighbors.
- Step 3** On the SSO device and the neighbor device, verify that the graceful restart function is shown as both advertised and received, and confirm the address families that have the graceful restart capability. If no address families are listed, BGP NSF does not occur either:

**Example:**

```
Device# show ip bgp neighbors
BGP neighbor is 192.0.2.3, remote AS 1, internal link
BGP version 4, remote router ID 192.0.2.4
BGP state = Established, up for 00:02:38
Last read 00:00:38, last write 00:00:35, hold time is 180, keepalive interval is 60
seconds
Neighbor capabilities:
Route refresh: advertised and received(new)
```

```

Address family IPv4 Unicast: advertised and received
Message statistics:
InQ depth is 0
OutQ depth is 0
Sent Rcvd
Opens: 1 1
Notifications: 0 0
Updates: 0 0
Keepalives: 4 4
Route Refresh: 0 0
Total: 5 5
Default minimum time between advertisement runs is 0 seconds
.....
(Remaining output deleted)

```

## Configuring OSPF NSF

All peer devices participating in OSPF NSF must be made OSPF NSF-aware, which happens automatically when you install an NSF software image on the device.

### Procedure

|               | Command or Action                                                                                                 | Purpose                                                                                |
|---------------|-------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><br><b>Example:</b><br>Device(config)# <b>configure terminal</b>                     | Enters global configuration mode.                                                      |
| <b>Step 2</b> | <b>router ospf <i>processID</i></b><br><br><b>Example:</b><br>Device(config)# <b>router ospf <i>processID</i></b> | Enables an OSPF routing process, which places the switch in router configuration mode. |
| <b>Step 3</b> | <b>nsf</b><br><br><b>Example:</b><br>Device(config)# <b>nsf</b>                                                   | Enables NSF operations for OSPF.                                                       |

## Verifying OSPF NSF

### Procedure

- Step 1** Verify that 'nsf' appears in the OSPF configuration of the SSO-enabled device by entering the show running-config command:

#### Example:

```

Device(config)#show running-config
route ospf 120
log-adjacency-changes
nsf

```

```

network 192.0.2.0 192.0.2.255 area 0
network 192.0.2.1 192.0.2.255 area 1
network 192.0.2.2 192.0.2.255 area 2
.
.
.

```

**Step 2** Enter the **show ip ospf** command to verify that NSF is enabled on the device:

**Example:**

```

Device show ip ospf
Routing Process "ospf 1" with ID 192.0.2.1
Start time: 00:02:07.532, Time elapsed: 00:39:05.052
Supports only single TOS(TOS0) routes
Supports opaque LSA
Supports Link-local Signaling (LLS)
transit capable is 0
External flood list length 0
IETF Non-Stop Forwarding enabled
restart-interval limit: 120 sec
IETF NSF helper support enabled
Cisco NSF helper support enabled
Reference bandwidth unit is 100 mbps
Area BACKBONE(0)
Number of interfaces in this area is 3 (1 loopback)
Area has no authentication
SPF algorithm last executed 00:08:53.760 ago
SPF algorithm executed 2 times
Area ranges are
Number of LSA 3. Checksum Sum 0x025BE0
Number of opaque link LSA 0. Checksum Sum 0x000000
Number of DCbitless LSA 0
Number of indication LSA 0
Number of DoNotAge LSA 0
Flood list length 0

```

## Configuring EIGRP NSF

### Procedure

|               | Command or Action                                                                                     | Purpose                                                                                     |
|---------------|-------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><br><b>Example:</b><br>Device <b>configure terminal</b>                  | Enters global configuration mode.                                                           |
| <b>Step 2</b> | <b>router eigrp as-number</b><br><br><b>Example:</b><br>Device(config)# <b>router eigrp as-number</b> | Enables an EIGRP routing process, which places the switch in router configuration mode.     |
| <b>Step 3</b> | <b>nsf</b><br><br><b>Example:</b><br>Device(config-router)# <b>nsf</b>                                | Enables EIGRP NSF.<br><br>Use this command on the “restarting” switch and all of its peers. |



# Verifying EIGRP NSF

## Procedure

---

- Step 1** Verify that “nsf” appears in the EIGRP configuration of the SSO-enabled device by entering the show **running-config** command:

**Example:**

```
Device show running-config
..
.
router eigrp 100
auto-summary
nsf
..
.
```

- Step 2** Enter the **show ip protocols** command to verify that NSF is enabled on the device:

**Example:**

```
Device show ip protocols
*** IP Routing is NSF aware ***
Routing Protocol is "ospf 1"
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Router ID 192.0.2.3
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
Maximum path: 1
Routing for Networks:
Routing on Interfaces Configured Explicitly (Area 0):
Loopback0
GigabitEthernet5/3
TenGigabitEthernet3/1
Routing Information Sources:
Gateway Distance Last Update
192.0.2.1 110 00:01:02
Distance: (default is 110)
Routing Protocol is "bgp 601"
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
IGP synchronization is disabled
Automatic route summarization is disabled
Neighbor(s):
Address FiltIn FiltOut DistIn DistOut Weight RouteMap
192.0.2.0
Maximum path: 1
Routing Information Sources:
Gateway Distance Last Update
192.0.2.0 20 00:01:03
Distance: external 20 internal 200 local 200
```

---





## CHAPTER 125

# Configuring Cisco StackWise Virtual

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## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Restrictions for Cisco StackWise Virtual

- The Federal Information Processing Standards (FIPS) is not supported on Cisco StackWise Virtual links.
- In Cisco IOS XE Denali 16.3.3, the maximum number of Cisco StackWise Virtual links supported is four.
- In Cisco IOS XE Denali 16.6.x, the maximum number of Cisco StackWise Virtual links supported is eight.
- Cisco StackWise Virtual is supported only on the following Cisco Catalyst 3850 Series Switch models.

| Release | Supported switch models |
|---------|-------------------------|
| 16.3.x  | WS-C3850-48XS-S         |
|         | WS-C3850-48XS-E         |
|         | WS-C3850-48XS-F-S       |
|         | WS-C3850-48XS-F-E       |
| 16.6.x  | WS-C3850-48XS-S         |
|         | WS-C3850-48XS-E         |
|         | WS-C3850-48XS-F-S       |
|         | WS-C3850-48XS-F-E       |

- The dual active and StackWise Virtual link configuration are performed dynamically and the device should be rebooted after configuration.
- The uplink ports on the switch do not support Dual-Active Detection.
- Cisco StackWise Virtual is supported in IP services and IP base licenses. The licenses must be matched between two Cisco StackWise Virtual member switches. License migration requires both Cisco StackWise Virtual member switches to be rebooted to activate the licenses.
- When deploying StackWise Virtual, ensure that VLAN ID 4094 is not used anywhere on the network. All inter-chassis system control communication between stack members is carried over the reserved VLAN ID 4094 from the global range.

## Prerequisites for Cisco StackWise Virtual

- All the switches in Cisco StackWise Virtual solution must be of the same switch model.
- All the switches in Cisco StackWise Virtual solution must be running the same license level.
- All the switches in Cisco StackWise Virtual must be running the same software version.

## Information About Cisco Stackwise Virtual

### StackWise Virtual Overview

Cisco StackWise Virtual is a network system virtualization technology that pairs two switches into one virtual switch. Switches in a Cisco StackWise Virtual solution simplify operational efficiency with a single control and management plane, scale system bandwidth with distributed forwarding plane, and assist in building resilient networks using the recommended network design. Cisco StackWise Virtual allows two physical switches to operate as a single logical virtual switch using a 40G or 10G Ethernet connection.

## Cisco StackWise Virtual Topology

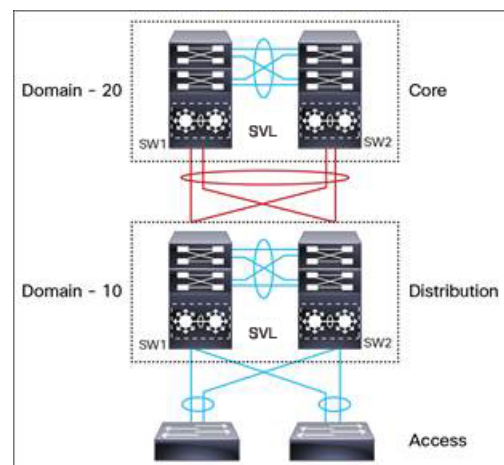
A typical network design consists of core, distribution, and access layers. The default mode of a switch is standalone. When two redundant switches are deployed in the distribution layer, the following network challenges arise:

- If VLAN IDs are reused between access layers then, it will introduce a spanning tree loop that will impact the overall performance of the network.
- Spanning tree protocols and configuration are required to protect Layer 2 network against spanning tree protocol loop, and root and bridge protocol data unit management.
- Additional protocols such as first hop redundancy protocol are required to virtualize the IP gateway function. This should align with STP root priorities for each VLAN.
- The Protocol independent multicast designated router (PIM DR) configuration should be fine-tuned to selectively build a multicast forwarding topology on a VLAN.
- The standalone distribution layer system provides protocol-driven remote failure and detection, which results in slower convergence time. Fine-tune FHRP and PIM timers for rapid fault detection and recovery process.

We recommend the Cisco StackWise Virtual model for aggregation layers and collapsed aggregation and core layers. The stack can be formed over a redundant 40G or 10G fiber links to ensure that the distribution or the aggregation switches can be deployed over a large distance.

Note that STP keeps one of the ports connected to the distribution switches blocked on the access switches. As a result of this, an active link failure causes STP convergence and the network suffers from traffic loss, flooding, and a possible transient loop in the network. On the other hand, if the switches are logically merged into one switch, all the access switches might form an EtherChannel bundle with distribution switches, and a link failure within an EtherChannel would not have any impact as long as at least one member within the EtherChannel is active.

**Figure 140: Typical Network Design using Cisco StackWise Virtual**



Etherchannel in StackWise Virtual is capable of implementing MEC across the stack members. When access layer and aggregation layer are collapsed into a single StackWise Virtual system, MEC across the different access layer domain members and across distribution and access layer switches will not be supported. MEC is designed to forward the traffic over the local link irrespective of the hash result.

Since the control plane, management plane, and data plane are integrated, the system behaves as a single switch.

The virtualization of multiple physical switches into a single logical switch is from a control and management plane perspective only. Because of the control plane being common, it may look like a single logical entity to peer switches. The data plane of the switches are distributed. Each switch is capable of forwarding over its local interfaces without involving other members. However, when a packet coming into a switch has to be forwarded over a different member's port, the forwarding context of the packet is carried over to the destination switch after ingress processing is performed in the ingress switch. Egress processing is done only in the egress switch. This provides a uniform data plane behavior to the entire switch irrespective whether of the destination port is in a local switch or in a remote switch. However, the common control plane ensures that all the switches have equivalent data plane entry for each forwarding entity.

An election mechanism elects one of the switches to be Cisco StackWise Virtual active and the other switch to be Cisco StackWise Virtual standby in terms of Control Plane functions. The active switch is responsible for all the management, bridging and routing protocols, and software data path. The standby switch is in hot standby state ready to take over the role of active, if the active switch fails over.

The following are the components of the Cisco StackWise Virtual solution:

- Stack members
- StackWise Virtual link: 10G or 40G Ethernet connections

StackWise Virtual link is the link that connects the switches over Ethernet. Typically, Cisco StackWise Virtual consists of multiple 10G or 40G physical links. It carries all the control and data traffic between the switching units. You can configure a StackWise Virtual link on any supported port. When a switch is powered up and the hardware is initialized, it looks for a configured StackWise Virtual link before the initialization of the control plane.

The Link Management Protocol (LMP) is activated on each link of the StackWise Virtual links as soon as the links are established. LMP ensure the integrity of SVL links and monitors and maintains the health of the links. The redundancy role of each switch is resolved by the StackWise Discovery Protocol (SDP). It ensures that the hardware and software versions are compatible to form the SVL and determines which switch becomes active or standby from a control plane perspective.

Cisco StackWise Virtual Header (SVH) is 64-byte overhead frame that is appended over all control, data, and management plane traffic that traverse over each SVL between the two stack members of the Cisco StackWise Virtual domain. The SVH-encapsulated traffic operates at OSI Layer 2 and can be recognized and processed only by Cisco StackWise Virtual-enabled switches. SVL interfaces are nonbridgeable, and allows nonrouteable traffic over a L2 or L3 network.

## Cisco StackWise Virtual Redundancy

Cisco StackWise Virtual operates stateful switchover (SSO) between the active and standby switches. The following are the ways in which Cisco StackWise Virtual's redundancy model differs from that of the standalone mode:

- The Cisco StackWise Virtual active and standby switches are hosted in separate switches and use a StackWise Virtual link to exchange information.
- The active switch controls both the switches of Cisco StackWise Virtual. The active switch runs the Layer 2 and Layer 3 control protocols and manages the switching modules of both the switches.

- The Cisco StackWise Virtual active and standby switches perform data traffic forwarding.



---

**Note** If the Cisco StackWise Virtual active switch fails, the standby switch initiates a switchover and assumes the Cisco StackWise Virtual active switch role.

---

## SSO Redundancy

A StackWise Virtual system operates with SSO redundancy if it meets the following requirements:

- Both the switches must be running the same software version, unless they are in the process of software upgrade.
- StackWise Virtual link-related configuration in the two switches must match.
- License type must be same on both the switch models.
- Both the switch models must be in the same StackWise Virtual domain.

With SSO redundancy, the StackWise Virtual standby switch is always ready to assume control if a fault occurs on the StackWise Virtual active switch. Configuration, forwarding, and state information are synchronized from the StackWise Virtual active switch to the redundant switch at startup, and whenever changes to the StackWise Virtual active switch configuration occur. If a switchover occurs, traffic disruption is minimized.

If StackWise Virtual does not meet the requirements for SSO redundancy, it will be incapable of establishing a relationship with the peer switch. StackWise Virtual runs stateful switchover (SSO) between the StackWise Virtual active and standby switches. The StackWise Virtual determines the role of each switch during initialization.

The CPU in the StackWise Virtual standby switch runs in hot standby state. StackWise Virtual uses a StackWise Virtual link to synchronize configuration data from the StackWise Virtual active switch to the StackWise Virtual standby switch. Also, protocols and features that support high availability synchronize their events and state information to the StackWise Virtual standby switch.

## Nonstop Forwarding

While implementing Nonstop Forwarding (NSF) technology in systems using SSO redundancy mode, network disruptions are transparent to campus users and applications. High availability is provided even when the control-plane processing stack-member switch is reset. During a failure of the underlying Layer 3, NSF-capable protocols perform graceful network topology resynchronization. The preset forwarding information on the redundant stack-member switch remains intact; this switch continues to forward the data in the network. This service availability significantly lowers the mean time to repair (MTTR) and increases the mean time between failure (MTBF) to achieve a high level of network availability.

## Multichassis EtherChannels

A Multichassis EtherChannel (MEC) is an EtherChannel bundled with physical ports having common characteristics such as speed and duplex, that are distributed across each Cisco StackWise Virtual system. A

Cisco StackWise Virtual MEC can connect to any network element that supports EtherChannel (such as a host, server, router, or switch). Cisco StackWise Virtual supports up to 128 MECs deployed in Layer 2 or Layer 3 modes. EtherChannel 128 is reserved for SVL connections. Hence, the maximum available MEC count is 127.

In a Cisco StackWise Virtual system, an MEC is an EtherChannel with additional capability. A multichassis EtherChannel link reduces the amount of traffic that requires transmission across the StackWise Virtual link by populating the index port only with the ports local to the physical switch. This allows the switch to give precedence to the local ports of the multichassis EtherChannel link over those on the remote switch.

Each MEC can optionally be configured to support either Cisco PAgP, IEEE LACP, or Static ON mode. We recommend that you implement EtherChannel using Cisco PAgP or LACP with a compatible neighbor. If a remotely connected neighbor such as Cisco Wireless LAN Controller (WLC) does not support this link-bundling protocol, then a Static ON mode can be deployed. These protocols run only on the Cisco StackWise Virtual active switch.

An MEC can support up to eight physical links that can be distributed in any proportion between the Cisco StackWise Virtual active switch and the Cisco StackWise Virtual standby switch. We recommend that you distribute the MEC ports across both switches evenly.

## MEC Minimum Latency Load Balancing

The StackWise Virtual environment is designed such that data forwarding always remains within the switch. The Virtual Stack always tries to forward traffic on the locally available links. This is true for both Layer 2 and Layer 3 links. The primary motivation for local forwarding is to avoid unnecessarily sending data traffic over the StackWise Virtual link and thus reduce the latency (extra hop over the SVL) and congestion. The bidirectional traffic is load-shared between the two StackWise Virtual members. However, for each StackWise Virtual member, ingress and egress traffic forwarding is based on locally-attached links that are part of MEC. This local forwarding is a key concept in understanding convergence and fault conditions in a StackWise Virtual enabled campus network.

The active and standby switches support local forwarding that will individually perform the desired lookups and forward the traffic on local links to uplink neighbors. If the destination is a remote switch in the StackWise Virtual domain, ingress processing is performed on the ingress switch and then traffic is forwarded over the StackWise Virtual link to the egress switch where only egress processing is performed.



---

**Note** Minimum Latency Load Balancing is not supported in Cisco IOS XE Denali 16.3.3.

---

## MEC Failure Scenarios

We recommend that you configure a MEC with at least one link to each switch. This configuration ensures that there is always an alternate path for data traffic in case of a switch failure.

The following sections describe issues that may arise and the resulting impact:

### Single MEC Link Failure

If a link within a MEC fails (and other links in the MEC are still operational), the MEC redistributes the load among the operational links, as in a regular port.



### **All MEC Links to the Cisco StackWise Virtual Active Switch Fail**

If all the links to the Cisco StackWise Virtual active switch fail, a MEC becomes a regular EtherChannel with operational links to the Cisco StackWise Virtual standby switch.

Data traffic that terminates on the Cisco StackWise Virtual active switch reaches the MEC by crossing a StackWise Virtual link to the Cisco StackWise Virtual standby switch. Control protocols continue to run in the Cisco StackWise Virtual active switch. Protocol messages reach the MEC by crossing a StackWise Virtual link.

### **All MEC Links Fail**

If all the links in an MEC fail, the logical interface for the EtherChannel is set to Unavailable. Layer 2 control protocols perform the same corrective action as for a link-down event on a regular EtherChannel.

On adjacent switches, routing protocols and the Spanning Tree Protocol (STP) perform the same corrective action as for a regular EtherChannel.

### **Cisco StackWise Virtual Standby Switch Failure**

If the Cisco StackWise Virtual standby switch fails, a MEC becomes a regular EtherChannel with operational links on the Cisco StackWise Virtual active switch. Connected peer switches detect the link failures, and adjust their load-balancing algorithms to use only the links to the StackWise Virtual active switch.

### **Cisco StackWise Virtual Active Switch Failure**

Cisco StackWise Virtual active switch failure results in a stateful switchover (SSO). After the switchover, a MEC is operational on the new Cisco StackWise Virtual active switch. Connected peer switches detect the link failures (to the failed switch), and adjust their load-balancing algorithms to use only the links to the new Cisco StackWise Virtual active switch.

## **Cisco StackWise Virtual Packet Handling**

In Cisco StackWise Virtual, the Cisco StackWise Virtual active switch runs the Layer 2 and Layer 3 protocols and features and manages the ports on both the switches.

Cisco StackWise Virtual uses StackWise Virtual link to communicate system and protocol information between the peer switches and to carry data traffic between the two switches.

The following sections describe packet handling in Cisco StackWise Virtual.

### **Traffic on a StackWise Virtual link**

A StackWise Virtual link carries data traffic and in-band control traffic between two switches. All the frames that are forwarded over the StackWise Virtual link are encapsulated with a special StackWise Virtual Header (SVH). The SVH adds an overhead of 64 bytes for control and data traffic, which provides information for Cisco StackWise Virtual to forward the packet on the peer switch.

A StackWise Virtual link transports control messages between two switches. Messages include protocol messages that are processed by the Cisco StackWise Virtual active switch, but received or transmitted by interfaces on the Cisco StackWise Virtual standby switch. Control traffic also includes module programming between the Cisco StackWise Virtual active switch and the switching modules on the Cisco StackWise Virtual standby switch.

Cisco StackWise Virtual transmits data traffic over a StackWise Virtual link under the following circumstances:

- Layer 2 traffic flooded over a VLAN (even for dual-homed links).
- Packets processed by software on the Cisco StackWise Virtual active switch where the ingress interface is on the Cisco StackWise Virtual standby switch.
- The packet destination is on the peer switch, as described in the following examples:
  - Traffic within a VLAN where the known destination interface is on the peer switch.
  - Traffic that is replicated for a multicast group and the multicast receivers are on the peer switch.
  - The known unicast destination MAC address is on the peer switch.
  - The packet is a MAC notification frame destined for a port on the peer switch.

A StackWise Virtual link also transports system data, such as NetFlow export data and SNMP data, from the Cisco StackWise Virtual standby switch to the Cisco StackWise Virtual active switch.

Traffic on the StackWise Virtual link is load balanced with the same global hashing algorithms available for EtherChannels (the default algorithm is source-destination IP).

## Layer 2 Protocols

The Cisco StackWise Virtual active switch runs the Layer 2 protocols (such as STP and VTP) for the switching modules on both the switches. Protocol messages that are transmitted and received on the Cisco StackWise Virtual standby switch switching modules must traverse a StackWise Virtual link to reach the Cisco StackWise Virtual active switch.

All the Layer 2 protocols in Cisco StackWise Virtual work similarly in standalone mode. The following sections describe the difference in behavior for some protocols in Cisco StackWise Virtual.

### Spanning Tree Protocol

The Cisco StackWise Virtual active switch runs the STP. The Cisco StackWise Virtual standby switch redirects the STP BPDUs across a StackWise Virtual link to the Stackwise Virtual active switch.

The STP bridge ID is commonly derived from the switch MAC address. To ensure that the bridge ID does not change after a switchover, Cisco StackWise Virtual continues to use the original switch MAC address for the STP Bridge ID.

### EtherChannel Control Protocols

Link Aggregation Control Protocol (LACP) and Port Aggregation Protocol (PAgP) packets contain a device identifier. Cisco StackWise Virtual defines a common device identifier for both the switches. Use either PAgP or LACP on Multi EtherChannels instead of mode ON, even if all the three modes are supported.



---

**Note** A new PAgP enhancement has been defined for assisting with dual-active scenario detection.

---

### Switched Port Analyzer

Switched Port Analyzer (SPAN) on StackWise Virtual link ports is not supported; SVL ports can be neither a SPAN source, nor a SPAN destination. Cisco StackWise Virtual supports all the SPAN features for non-SVL interfaces. The number of SPAN sessions that are available on Cisco StackWise Virtual matches that on a single switch running in standalone mode.

### Private VLANs

Private VLANs on Stackwise Virtual work the same way as in standalone mode. The only exception is that the native VLAN on isolated trunk ports must be configured explicitly.

Apart from STP, EtherChannel Control Protocols, SPAN, and private VLANs, the Dynamic Trunking Protocol (DTP), Cisco Discovery Protocol (CDP), VLAN Trunk Protocol (VTP), and Unidirectional Link Detection Protocol (UDLD) are the additional Layer 2 control-plane protocols that run over the SVL connections.

## Layer 3 Protocols

The Cisco StackWise Virtual active switch runs the Layer 3 protocols and features for the Stackwise Virtual. All the Layer 3 protocol packets are sent to and processed by the Cisco StackWise Virtual active switch. Both the member switches perform hardware forwarding for ingress traffic on their interfaces. When software forwarding is required, packets are sent to the Cisco StackWise Virtual active switch for processing.

The same router MAC address assigned by the Cisco StackWise Virtual active switch is used for all the Layer 3 interfaces on both the Cisco StackWise Virtual member switches. After a switchover, the original router MAC address is still used. The router MAC address is chosen based on chassis-mac and is preserved after switchover by default.

The following sections describe the Layer 3 protocols for Cisco StackWise Virtual.

### IPv4 Unicast

The CPU on the Cisco StackWise Virtual active switch runs the IPv4 routing protocols and performs any required software forwarding. All the routing protocol packets received on the Cisco StackWise Virtual standby switch are redirected to the Cisco StackWise Virtual active switch across the StackWise Virtual link. The Cisco StackWise Virtual active switch generates all the routing protocol packets to be sent out over ports on either of the Cisco StackWise Virtual member switches.

Hardware forwarding is distributed across both members on Cisco StackWise Virtual. The CPU on the Cisco StackWise Virtual active switch sends Forwarding Information Base (FIB) updates to the Cisco StackWise Virtual standby switch, which in turn installs all the routes and adjacencies into hardware.

Packets intended for a local adjacency (reachable by local ports) are forwarded locally on the ingress switch. Packets intended for a remote adjacency (reachable by remote ports) must traverse the StackWise Virtual link.

The CPU on the Cisco StackWise Virtual active switch performs all software forwarding and feature processing (such as fragmentation and Time to Live exceed functions). If a switchover occurs, software forwarding is disrupted until the new Cisco StackWise Virtual active switch obtains the latest Cisco Express Forwarding and other forwarding information.

In virtual switch mode, the requirements to support non-stop forwarding (NSF) match those in the standalone redundant mode of operation.

From a routing peer perspective, Multi-Chassis EtherChannels (MEC) remain operational during a switchover, that is, only the links to the failed switch are down, but the routing adjacencies remain valid.

Cisco StackWise Virtual achieves Layer 3 load balancing over all the paths in the Forwarding Information Base entries, be it local or remote.

### IPv6

Cisco StackWise Virtual supports IPv6 unicast and multicast because it is present in the standalone system.

### IPv4 Multicast

The IPv4 multicast protocols run on the Cisco StackWise Virtual active switch. Internet Group Management Protocol (IGMP) and Protocol Independent Multicast (PIM) protocol packets received on the Cisco StackWise Virtual standby switch are transmitted across a StackWise Virtual link to the Stackwise Virtual active switch. The latter generates IGMP and PIM protocol packets to be sent over ports on either of the Cisco StackWise Virtual members.

The Cisco StackWise Virtual active switch synchronizes the Multicast Forwarding Information Base (MFIB) state to the Cisco StackWise Virtual standby switch. On both the member switches, all the multicast routes are loaded in the hardware, with replica expansion table (RET) entries programmed for only local, outgoing interfaces. Both the member switches are capable of performing hardware forwarding.



#### Note

To avoid multicast route changes as a result of a switchover, we recommend that all the links carrying multicast traffic be configured as MEC rather than Equal Cost Multipath (ECMP).

For packets traversing a StackWise Virtual link, all Layer 3 multicast replications occur on the egress switch. If there are multiple receivers on the egress switch, only one packet is replicated and forwarded over the StackWise Virtual link, and then replicated to all the local egress ports.

### Software Features

Software features run only on the Cisco StackWise Virtual active switch. Incoming packets to the Cisco StackWise Virtual standby switch that require software processing are sent across a StackWise Virtual link to the Cisco StackWise Virtual active switch.

## Dual-Active Detection

If the standby switch detects a complete loss of the StackWise Virtual link, it assumes the active switch has failed and will take over as the active switch. However, if the original Cisco StackWise Virtual active switch is still operational, both the switches will now be Cisco StackWise Virtual active switches. This situation is called a dual-active scenario. This scenario can have adverse effects on network stability because both the switches use the same IP addresses, SSH keys, and STP bridge IDs. Cisco StackWise Virtual detects a dual-active scenario and takes recovery action. Dual-active-detection link is the dedicated link used to mitigate this.

If a StackWise Virtual link fails, the Cisco StackWise Virtual standby switch cannot determine the state of the Cisco StackWise Virtual active switch. To ensure that switchover occurs without delay, the Cisco StackWise Virtual standby switch assumes that the Cisco StackWise Virtual active switch has failed and initiates switchover to take over the Cisco StackWise Virtual active role. The original Cisco StackWise Virtual active switch enters recovery mode and brings down all the interfaces except the StackWise Virtual link and the management interfaces.

## Dual-Active-Detection Link with Fast Hello



---

**Note** In Cisco IOS XE Denali 16.3.3, only the fast hello dual-active-detection method is supported.

---

To use the dual-active fast hello packet detection method, you must provision a direct ethernet connection between the two Cisco StackWise Virtual switches. You can dedicate up to four links for this purpose.

The two switches periodically exchange special dual-active hello messages containing information about the switch state. If all Stackwise Virtual Links fail and a dual-active scenario occurs, each switch recognizes that there is a dual-active scenario from the peer's messages. This initiates recovery actions as described in the [Recovery Actions, on page 2343](#) section. If a switch does not receive an expected dual-active fast hello message from the peer before the timer expires, the switch assumes that the link is no longer capable of dual-active detection.



---

**Note** Do not use the same port for StackWise Virtual link and dual-active detection link.

---

## Recovery Actions

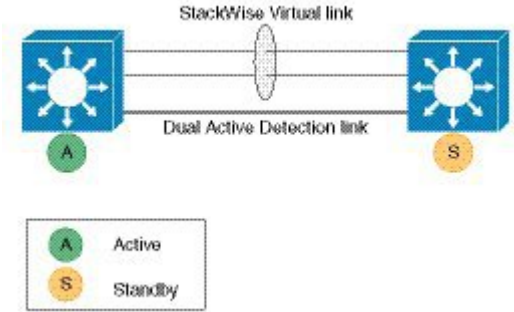
A Cisco Stackwise Virtual active switch that detects a dual-active condition shuts down all of its non-StackWise Virtual Link interfaces to remove itself from the network. The switch then waits in recovery mode until the StackWise Virtual links have been recovered. You should physically repair the StackWise Virtual link failure and the recovery switch should be manually reloaded for it to be the standby switch.

## Implementing Cisco StackWise Virtual

The two-node solution of Cisco StackWise Virtual is normally deployed at the aggregation layer. Two switches are connected over a StackWise Virtual link (SVL).

Cisco StackWise Virtual combines the two switches into a single logical switch with a large number of ports, offering a single point of management. One of the member switches is the control and management plane master, while the other one is the standby. The virtualization of multiple physical switches into a single logical switch is only from a control and management perspective. Because of the control plane being common, it may look like a single logical entity to peer switches. The data plane of the switches are converged, that is, the forwarding context of a switch might be passed to the other member switch for further processing when traffic is forwarded across the switches. However, the common control plane ensures that all the switches have equivalent data plane entry for each forwarding entity.

Figure 141: Two-Node Solution



An election mechanism that determines which switch has Cisco StackWise Virtual active and which one is a control plane standby, is available. The active switch is responsible for management, bridging and routing protocols, and software data path. These are centralized on the active switch supervisor of the Cisco StackWise Virtual active switch.

# How to Configure Cisco StackWise Virtual

## Configuring Cisco StackWise Virtual Settings

To enable StackWise Virtual, perform the following procedure:

**Procedure**

|               | Command or Action                                                                       | Purpose                                                                                                            |
|---------------|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br>Device> <b>enable</b>                               | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul> |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>       | Enters global configuration mode.                                                                                  |
| <b>Step 3</b> | <b>stackwise-virtual</b><br><b>Example:</b><br>Device(config)# <b>stackwise-virtual</b> | Enables Cisco StackWise Virtual and enters stackwise-virtual submode.                                              |

|               | Command or Action                                                                                          | Purpose                                                                                                                            |
|---------------|------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 4</b> | <b>domain</b> <i>id</i><br><b>Example:</b><br>Device(config-stackwise-virtual) # <b>domain</b><br><b>2</b> | (Optional) Specifies the Cisco StackWise Virtual domain ID.<br><br>The domain ID range is from 1 to 255. The default value is one. |

### What to do next

After the Cisco StackWise Virtual is enabled and the required interfaces are configured on to Cisco StackWise Virtual links, use the **show stackwise-virtual** command to verify the configured information. After verification, save the configuration and reboot the switches to form the stack.

## Configuring Cisco StackWise Virtual Link



**Note** Cisco StackWise Virtual is supported on port values ranging from 45 to 48 of the 10G interfaces and on all the 40G interfaces.



**Note** Cisco StackWise Virtual link is supported on all 10G interfaces, and 40G interfaces. However, a combination of both interfaces is not supported.

To configure a 10 Gigabit Ethernet port as a StackWise Virtual link port, perform the following procedure:

### Procedure

|               | Command or Action                                                                                                                                      | Purpose                                                                                                                                                                       |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br>Device> <b>enable</b>                                                                                              | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>                                                            |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                                      | Enters global configuration mode.                                                                                                                                             |
| <b>Step 3</b> | <b>interface TenGigabitEthernet</b> <i>&lt;interface&gt;</i><br><b>Example:</b><br>Device(config) # <b>interface</b><br><b>TenGigabitEthernet1/0/2</b> | Enters 10G ethernet interface configuration mode.<br><br>You can use the <b>interface FortyGigabitEthernet</b> <i>&lt;interface&gt;</i> command for a 40G ethernet interface. |

|               | Command or Action                                                                                                            | Purpose                                                                                                                                                                                                                                    |
|---------------|------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 4</b> | <b>stackwise-virtual link</b> <i>link value</i><br><b>Example:</b><br>Device(config-if) # <b>stackwise-virtual link</b><br>1 | Associates the interface with configured StackWise Virtual link.                                                                                                                                                                           |
| <b>Step 5</b> | <b>end</b><br><b>Example:</b><br>Device(config-if) # <b>end</b>                                                              | Returns to privileged EXEC mode.                                                                                                                                                                                                           |
| <b>Step 6</b> | <b>write memory</b><br><b>Example:</b><br>Device# <b>write memory</b>                                                        | Saves the running-configuration which resides in the system RAM to the startup-configuration in the system NVRAM. If you do not save the changes, the changes will no longer be part of the startup configuration when the switch reloads. |
| <b>Step 7</b> | <b>reload</b><br><b>Example:</b><br>Device# <b>reload</b>                                                                    | Restarts the switch.                                                                                                                                                                                                                       |

## Configuring a StackWise Virtual Dual-Active-Detection link

To configure a 10 Gigabit Ethernet port as StackWise dual-active-detection link, perform the following procedure. This procedure is optional.

### Procedure

|               | Command or Action                                                                 | Purpose                                                                                                            |
|---------------|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br>Device> <b>enable</b>                         | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul> |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b> | Enters global configuration mode.                                                                                  |
| <b>Step 3</b> | <b>interface TenGigabitEthernet</b> <interface><br><b>Example:</b>                | Enters a 10G interface configuration mode.                                                                         |



|               | Command or Action                                                                                                                                 | Purpose                                                                                                                                                                                                                                    |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | <pre>Device(config)#interface TenGigabitEthernet1/0/41</pre>                                                                                      | <p><b>Note</b> 1G interfaces can also be configured as Dual-active detection link.</p> <p>You must use different ports for StackWise Virtual link and dual-active detection link.</p>                                                      |
| <b>Step 4</b> | <p><b>stackwise-virtual dual-active-detection</b></p> <p><b>Example:</b></p> <pre>Device(config-if)#stackwise-virtual dual-active-detection</pre> | <p>Associates the interface with StackWise Virtual dual-active-detection.</p> <p><b>Note</b> This command will not be visible on the device after the configuration, but will continue to function.</p>                                    |
| <b>Step 5</b> | <p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-if)#end</pre>                                                                         | Returns to privileged EXEC mode.                                                                                                                                                                                                           |
| <b>Step 6</b> | <p><b>write memory</b></p> <p><b>Example:</b></p> <pre>Device#write memory</pre>                                                                  | Saves the running-configuration which resides in the system RAM to the startup-configuration in the system NVRAM. If you do not save the changes, the changes will no longer be part of the startup configuration when the switch reloads. |
| <b>Step 7</b> | <p><b>reload</b></p> <p><b>Example:</b></p> <pre>Device#reload</pre>                                                                              | Restarts the switch.                                                                                                                                                                                                                       |

## Verifying Cisco StackWise Virtual Configuration

To verify your Stackwise Virtual configuration, use the following **show** commands:

|                                                          |                                                                   |
|----------------------------------------------------------|-------------------------------------------------------------------|
| <b>show stackwise-virtual switch</b> <i>number</i> <1-2> | Displays information of a particular switch in the stack.         |
| <b>show stackwise-virtual link</b>                       | Displays StackWise Virtual link information.                      |
| <b>show stackwise-virtual bandwidth</b>                  | Displays the bandwidth available for the Cisco StackWise Virtual. |
| <b>show stackwise-virtual neighbors</b>                  | Displays the Cisco StackWise Virtual neighbors.                   |
| <b>show stackwise-virtual dual-active-detection</b>      | Displays Stackwise Virtual dual-active-detection information.     |
| <b>show stackwise-virtual dual-active-detection pagp</b> | Displays ePAGP dual-active-detection information.                 |

# Feature Information for Cisco StackWise Virtual

| Release                      | Modification                                                                                                            |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------|
| Cisco IOS XE Denali 16.3.3   | This feature was introduced.                                                                                            |
| Cisco IOS XE Everest 16.5.1a | This feature was not supported.                                                                                         |
| Cisco IOS XE Everest 16.6.1  | This feature was reintroduced.<br>Minimum Latency Load Balancing and Dual-active-detection using ePAgP were introduced. |



## CHAPTER 126

# Configuring Wireless High Availability

- [Finding Feature Information, on page 2349](#)
- [Information about High Availability, on page 2349](#)
- [Information About Redundancy, on page 2350](#)
- [Information about Access Point Stateful Switch Over , on page 2351](#)
- [Initiating Graceful Switchover, on page 2352](#)
- [Configuring EtherChannels for High Availability, on page 2352](#)
- [Configuring LACP, on page 2353](#)
- [Troubleshooting High Availability, on page 2354](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information about High Availability

The high availability feature is enabled by default when the devices are connected using the stack cable and the Cisco StackWise-480 technology is enabled. You cannot disable it; however, you can initiate a manual graceful-switchover using the command line interface to use the high availability feature enabled in the .

In Cisco Wireless LAN Controllers, high availability is achieved with redundancy.

In Cisco Wireless LAN Controllers, redundancy is achieved in two ways— n+1 and AP SSO redundancy.

Keepalive messages are sent and received between the active and standby controllers.

- If the standby controller does not respond, a new standby controller is elected.
- If the active controller does not respond, the standby controller becomes the active controller.

In addition, hello messages are sent and received by all stack members.

- If a stack member does not respond, that member is removed from the stack.

- If the standby controller does not respond, a new standby controller is elected.
- If the active controller does not respond, the standby controller becomes the active controller.

## Information About Redundancy

In case of n+1 redundancy, access points are configured with primary, secondary, and tertiary controllers. When the primary controller fails, depending upon the number of access points managed by a controller, the access point fails over to the secondary controller. In case of AP SSO redundancy, once the primary controller is unavailable, the access points re-discover the controller and reestablishes the CAPWAP tunnel with the secondary controller. However, all clients must disconnect and a re-authentication is performed to rejoin the controller.

You can configure primary, secondary, and tertiary controllers for a selected access point and a selected controller.

In an ideal high availability deployment, you can have access points connected to primary and secondary controllers and one controller can remain with out connection to any access points. This way the controller that does not have any access points can take over when a failure occurs and resume services of active controller.

## Configuring Redundancy in Access Points

You must use the commands explained in this section to configure primary, secondary, or tertiary controllers for a selected access point.

### Before you begin

### Procedure

|               | Command or Action                                                                                                                 | Purpose                                                            |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| <b>Step 1</b> | <pre>conf t</pre> <p><b>Example:</b></p> <pre>Controller # conf t</pre>                                                           | Configures the terminal                                            |
| <b>Step 2</b> | <pre>ap capwap backup primary</pre> <p><b>Example:</b></p> <pre>Controller # ap capwap backup primary WLAN-Controller-A</pre>     | Configures the primary controller for the selected access point.   |
| <b>Step 3</b> | <pre>ap capwap backup secondary</pre> <p><b>Example:</b></p> <pre>Controller # ap capwap backup secondary WLAN-Controller-B</pre> | Configures the secondary controller for the selected access point. |
| <b>Step 4</b> | <pre>ap capwap backup tertiary</pre> <p><b>Example:</b></p> <pre>Controller # ap capwap backup tertiary WLAN-Controller-C</pre>   | Configures the tertiary controller for the selected access point.  |

**What to do next**

Once you complete configuration of the primary, secondary, and tertiary controllers for a selected access point, you must verify the configuration using the **show ap name** *AP-NAME* command. For more details on, **show ap name** *AP-NAME* command, see the Lightweight Access Point Configuration Guide for Cisco Wireless LAN Controller.

.

## Configuring Heartbeat Messages

Heartbeat messages enable you to reduce the controller failure detection time. When a failure occurs, a switchover from active to hot standby happens after the controller waits for the heartbeat timer. If the controller does not function within the heartbeat time, then the standby takes over as then active controller. Ideally the access point generates three heartbeat messages within the time out value specified, and when the controller does not respond within the timeout value, the standby controller takes over as active. You can specify the timeout value depending on your network. Ideally the timer value is not a higher value as some chaos will occur while performing a switchover. This section explains on how to configure heartbeat interval between the controller and the access points using a timeout value to reduce the controller failure detection time.

**Before you begin****Procedure**

|               | Command or Action                                                                                                               | Purpose                                                                                                            |
|---------------|---------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <pre>conf t</pre> <p><b>Example:</b></p> <pre>controller # conf t</pre>                                                         | Configures the terminal.                                                                                           |
| <b>Step 2</b> | <pre>ap capwap timers heartbeat-timeout</pre> <p><b>Example:</b></p> <pre>controller # ap capwap timers heartbeat-timeout</pre> | Configures the heartbeat interval between the controller and access points. The timeout value ranges from 1 to 30. |

## Information about Access Point Stateful Switch Over

An Access Point Stateful Switch Over (AP SSO) implies that all the access point sessions are switched over state-fully and the user session information is maintained during a switchover, and access points continue to operate in network with no loss of sessions, providing improved network availability. The active in the stack is equipped to perform all network functions, including IP functions and routing information exchange. The supports 1000 access points and 12000 clients.

However, all the clients are de-authenticated and need to be re-associated with the new active except for the locally switched clients in FlexConnect mode when a switchover occurs.

Once a redundancy pair is formed while in a stack, high availability is enabled, which includes that access points continue to remain connected during an active-to-standby switchover.



**Note** You can not disable AP SSO while in a stack once the devices form a redundant pair.



**Note** After switchover new standby gets reloaded during stack formation, this is due to bulk sync failure. This is seen after reload, 2nd attempt to form stack successfully. This happens when you execute the command *exception dump device second flash* which is used to enable, dump crashfile on flash when crashinfo directory is full. When crash occurs and if there is no space left in crashinfo, it proceeds to store the fullcore or crash files into flash.

# Initiating Graceful Switchover

To perform a manual switchover and to use the high availability feature enabled in the , execute the **redundancy force-switchover** command. This command initiates a graceful switchover from the active to the standby .

```
Device# redundancy force-switchover
System configuration has been modified. Save ? [yes/no] : yes
Building configuration ...
Preparing for switchover ...
Compressed configuration from 14977 bytes to 6592 bytes[OK]This will reload the active unit
and force switchover to standby[confirm] : y
```

### Procedure

|        | Command or Action | Purpose |
|--------|-------------------|---------|
| Step 1 |                   |         |

# Configuring EtherChannels for High Availability

The LAG, or an EtherChannel, bundles all the existing ports in both the standby and active units into a single logical port to provide an aggregate bandwidth of 60 Gbps. The creation of an EtherChannel enables protection against failures. The EtherChannels or LAGs created are used for link redundancy to ensure high availability of access points.

For more details on configuring EtherChannel, and Etherchannel modes, see the [Layer 2 \(Link Aggregation\) Configuration Guide, Cisco IOS XE Release 3SE \(Cisco WLC 5700 Series\)](#)

### Procedure

- Step 1** Connect two devices that are in powered down state using the stack cable.
- Step 2** Power up and perform a boot on both devices simultaneously or power and boot one .  
The devices boot up successfully, and form a high availability pair.
- Step 3** Configure EtherChannel or LAG on the units.

- Step 4** Use the **show etherchannel summary** command to view the status of the configured EtherChannel.
- On successful configuration, all the specified ports will be bundled in a single channel and listed in the command output of **show etherchannel summary**.
- Step 5** Execute the **show ap uptime** command to verify the connected access points.

## Configuring LACP

### Procedure

|               | Command or Action                                                                                                             | Purpose                                                                                                          |
|---------------|-------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                             | Enters global configuration mode.                                                                                |
| <b>Step 2</b> | <b>interface port-channel <i>number</i></b><br><b>Example:</b><br>Device(config)# <b>interface Port-channel Po2</b>           | Enters port-channel interface configuration mode.                                                                |
| <b>Step 3</b> | <b>lACP max-bundle <i>number</i></b><br><b>Example:</b><br>Device(config-if)# <b>lACP max-bundle 6</b>                        | Defines the maximum number of active bundled LACP ports allowed in a port channel. The value ranges from 1 to 8. |
| <b>Step 4</b> | <b>lACP port-priority <i>number</i></b><br><b>Example:</b><br>Device(config-if)# <b>lACP port-priority 4</b>                  | Specifies port priority to be configured on the port using LACP. The value ranges from 0 to 65535.               |
| <b>Step 5</b> | <b>switchport backup interface <i>po2</i></b><br><b>Example:</b><br>Device(config-if)# <b>switchport backup interface Po2</b> | Specifies an interface as the backup interface.                                                                  |
| <b>Step 6</b> | <b>end</b>                                                                                                                    | Exits the interface and configuration mode.                                                                      |
| <b>Step 7</b> | <b>show etherchannel summary</b><br><b>Example:</b><br>Device# <b>show etherchannel summary</b>                               | Displays a summary of EtherChannel properties.                                                                   |
| <b>Step 8</b> | <b>show interfaces switchport backup</b><br><b>Example:</b><br>Device# <b>show interfaces switchport backup</b>               | Displays summary of backup EtherChannel properties.                                                              |

# Troubleshooting High Availability

## Access the Standby Console

You can only access the console of the active in a stack. To access the standby, use the following commands.

### Before you begin

Use this functionality only under supervision of Cisco Support.

### Procedure

|               | Command or Action                                                                                       | Purpose                                           |
|---------------|---------------------------------------------------------------------------------------------------------|---------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <code>configure terminal</code>                 | Enters global configuration mode.                 |
| <b>Step 2</b> | <b>service internal</b><br><b>Example:</b><br>Device(config)# <code>service internal</code>             | Enables Cisco IOS debug commands.                 |
| <b>Step 3</b> | <b>redundancy</b><br><b>Example:</b><br>Device(config)# <code>redundancy</code>                         | Enters redundancy configuration mode.             |
| <b>Step 4</b> | <b>main-cpu</b><br><b>Example:</b><br>Device(config)# <code>main-cpu</code>                             | Enters the redundancy main configuration submode. |
| <b>Step 5</b> | <b>standby console enable</b><br><b>Example:</b><br>Device(config)# <code>standby console enable</code> | Enables the standby console.                      |
| <b>Step 6</b> | <b>exit</b><br><b>Example:</b><br>Device(config)# <code>exit</code>                                     | Exits the configuration mode.                     |

## Before a Switchover

A switchover happens when the active fails; however, while performing a manual switchover, you can execute these commands to initiate a successful switchover:



**Procedure**

|               | <b>Command or Action</b>                                                                            | <b>Purpose</b>                                                                                                                                                                                                                     |
|---------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>show redundancy states</b><br><b>Example:</b><br>Device# <code>show redundancy states</code>     | Displays the high availability role of the active and standby devices.                                                                                                                                                             |
| <b>Step 2</b> | <b>show switch detail</b><br><b>Example:</b><br>Device# <code>show switch detail</code>             | Display physical property of the stack. Verify if the physical states of the stacks are "Ready" or "Port".                                                                                                                         |
| <b>Step 3</b> | <b>show platform ses states</b><br><b>Example:</b><br>Device# <code>show platform ses states</code> | Displays the sequences of the stack manager.                                                                                                                                                                                       |
| <b>Step 4</b> | <b>show ap summary</b><br><b>Example:</b><br>Device# <code>show ap summary</code>                   | Displays all the access points in the active and standby devices.                                                                                                                                                                  |
| <b>Step 5</b> | <b>show capwap detail</b><br><b>Example:</b><br>Device# <code>show capwap detail</code>             | Displays the details of the CAPWAP tunnel in the active and standby devices.                                                                                                                                                       |
| <b>Step 6</b> | <b>show dtls database-brief</b><br><b>Example:</b><br>Device# <code>show dtls database-brief</code> | Displays DTLS details in the active and standby devices.                                                                                                                                                                           |
| <b>Step 7</b> | <b>show power inline</b><br><b>Example:</b><br>Device# <code>show power inline</code>               | Displays the power on Ethernet power state.<br><br><b>Note</b> When a failover occurs, the standby controller must be in a standby-hot state and the redundant port in a terminal state in SSO for successful switchover to occur. |

**After a Switchover**

This section defines the steps that you must perform to ensure that successful switchover from the active to standby is performed. On successful switchover of the standby as active, all access points connected to the active need to re-join the standby (then active) .

**Procedure**

|               | <b>Command or Action</b>                 | <b>Purpose</b>                                                                 |
|---------------|------------------------------------------|--------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>show ap uptime</b><br><b>Example:</b> | Verify if the uptime of the access point after the switchover is large enough. |

|               | Command or Action                                                                               | Purpose                                       |
|---------------|-------------------------------------------------------------------------------------------------|-----------------------------------------------|
|               | Device# <code>show ap uptime</code>                                                             |                                               |
| <b>Step 2</b> | <b>show wireless summary</b><br><b>Example:</b><br>Device# <code>show wireless summary</code>   | Display the clients connected in the active . |
| <b>Step 3</b> | <b>show wcdb database all</b><br><b>Example:</b><br>Device# <code>show wcdb database all</code> | Display if the client has reached the uptime. |
| <b>Step 4</b> | <b>show power inline</b><br><b>Example:</b><br>Device# <code>show power inline</code>           | Display the power over Ethernet power state.  |

## Monitoring the Device Stack

Table 185: Commands for Displaying Stack Information

| Command                                          | Description                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>show switch</b>                               | Displays summary information about the stack, including the status of provisioned switches and switches in version-mismatch mode.                                                                                                                                                                                                                                   |
| <b>show switch</b><br><i>stack-member-number</i> | Displays information about a specific member.                                                                                                                                                                                                                                                                                                                       |
| <b>show switch detail</b>                        | Displays detailed information about the stack.                                                                                                                                                                                                                                                                                                                      |
| <b>show switch neighbors</b>                     | Displays the stack neighbors.                                                                                                                                                                                                                                                                                                                                       |
| <b>show switch stack-ports</b><br>[summary]      | Displays port information for the stack. Use the <b>summary</b> keyword to display the stack cable length, the stack link status, and the loopback status.                                                                                                                                                                                                          |
| <b>show redundancy</b>                           | Displays the redundant system and the current processor information. The redundant system information includes the system uptime, standby failures, switchover reason, hardware, configured and operating redundancy mode. The current processor information displayed includes the active location, the software state, the uptime in the current state and so on. |
| <b>show redundancy state</b>                     | Displays all the redundancy states of the active and standby devices.                                                                                                                                                                                                                                                                                               |

## LACP Configuration: Example

This example shows how to configure LACP and to verify creation of the LACP bundle and the status:

```
Device(config)# !
interface TenGigabitEthernet1/0/1
  switchport mode trunk
  channel-group 1 mode active
  lacp port-priority 10
  ip dhcp snooping trust
!
interface TenGigabitEthernet1/0/2
  switchport mode trunk
  channel-group 1 mode active
  lacp port-priority 10
  ip dhcp snooping trust
!
interface TenGigabitEthernet1/0/3
  switchport mode trunk
  channel-group 1 mode active
  lacp port-priority 10
  ip dhcp snooping trust
!
interface TenGigabitEthernet1/0/4
  switchport mode trunk
  channel-group 1 mode active
  ip dhcp snooping trust
!
interface TenGigabitEthernet1/0/5
  switchport mode trunk
  channel-group 1 mode active
  ip dhcp snooping trust
!
interface TenGigabitEthernet1/0/6
  switchport mode trunk
  channel-group 1 mode active
  ip dhcp snooping trust
!
interface TenGigabitEthernet2/0/1
  switchport mode trunk
  channel-group 1 mode active
  lacp port-priority 10
  ip dhcp snooping trust
!
interface TenGigabitEthernet2/0/2
  switchport mode trunk
  channel-group 1 mode active
  lacp port-priority 10
  ip dhcp snooping trust
!
interface TenGigabitEthernet2/0/3
  switchport mode trunk
  channel-group 1 mode active
  lacp port-priority 10
  ip dhcp snooping trust
!
interface TenGigabitEthernet2/0/4
  switchport mode trunk
  channel-group 1 mode active
  ip dhcp snooping trust
!
interface TenGigabitEthernet2/0/5
  switchport mode trunk
  channel-group 1 mode active
  ip dhcp snooping trust
!
interface TenGigabitEthernet2/0/6
  switchport mode trunk
```

```

channel-group 1 mode active
ip dhcp snooping trust
!
interface Vlan1
no ip address
ip igmp version 1
shutdown
!

```

Device# **show etherchannel summary**

```

Flags: D - down          P - bundled in port-channel
       I - stand-alone  s - suspended
       H - Hot-standby (LACP only)
       R - Layer3       S - Layer2
       U - in use       f - failed to allocate aggregator

       M - not in use, minimum links not met
       u - unsuitable for bundling
       w - waiting to be aggregated
       d - default port

```

```

Number of channel-groups in use: 1
Number of aggregators:          1

```

| Group | Port-channel | Protocol | Ports       |             |             |
|-------|--------------|----------|-------------|-------------|-------------|
| 1     | Pol(SU)      | LACP     | Tel/0/1 (P) | Tel/0/2 (P) | Tel/0/3 (P) |
|       |              |          | Tel/0/4 (H) | Tel/0/5 (H) | Tel/0/6 (H) |
|       |              |          | Te2/0/1 (P) | Te2/0/2 (P) | Te2/0/3 (P) |
|       |              |          | Te2/0/4 (H) | Te2/0/5 (H) | Te2/0/6 (H) |

This example shows the switch backup interface pairs:

Device# show interfaces switchport backup

Switch Backup Interface Pairs:

| Active Interface | Backup Interface | State                    |
|------------------|------------------|--------------------------|
| Port-channell    | Port-channel2    | Active Standby/Backup Up |

This example shows the summary of the EtherChannel configured in the :

Device# show ethernet summary

```

Flags: D - down          P - bundled in port-channel
       I - stand-alone  s - suspended
       H - Hot-standby (LACP only)
       R - Layer3       S - Layer2
       U - in use       f - failed to allocate aggregator

       M - not in use, minimum links not met
       u - unsuitable for bundling
       w - waiting to be aggregated
       d - default port

```

```

Number of channel-groups in use: 2
Number of aggregators:          2

```

| Group | Port-channel | Protocol | Ports |
|-------|--------------|----------|-------|
|-------|--------------|----------|-------|







## PART **XIX**

# System Management

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## CHAPTER 127

# Administering the Switch

---

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- [Monitoring and Maintaining Administration of the Device, on page 2389](#)
- [Configuration Examples for Device Administration, on page 2390](#)
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## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Administering the Device

### System Time and Date Management

You can manage the system time and date on your device using automatic configuration methods (RTC and NTP), or manual configuration methods.



---

**Note** For complete syntax and usage information for the commands used in this section, see the *Cisco IOS Configuration Fundamentals Command Reference* on *Cisco.com*.

---

## System Clock

The basis of the time service is the system clock. This clock runs from the moment the system starts up and keeps track of the date and time.

The system clock can then be set from these sources:

- NTP
- Manual configuration

The system clock can provide time to these services:

- User **show** commands
- Logging and debugging messages

The system clock keeps track of time internally based on Coordinated Universal Time (UTC), also known as Greenwich Mean Time (GMT). You can configure information about the local time zone and summer time (daylight saving time) so that the time appears correctly for the local time zone.

The system clock keeps track of whether the time is *authoritative* or not (that is, whether it has been set by a time source considered to be authoritative). If it is not authoritative, the time is available only for display purposes and is not redistributed.

## Network Time Protocol

The NTP is designed to time-synchronize a network of devices. NTP runs over User Datagram Protocol (UDP), which runs over IP. NTP is documented in RFC 1305.

An NTP network usually gets its time from an authoritative time source, such as a radio clock or an atomic clock attached to a time server. NTP then distributes this time across the network. NTP is extremely efficient; no more than one packet per minute is necessary to synchronize two devices to within a millisecond of one another.

NTP uses the concept of a *stratum* to describe how many NTP hops away a device is from an authoritative time source. A stratum 1 time server has a radio or atomic clock directly attached, a stratum 2 time server receives its time through NTP from a stratum 1 time server, and so on. A device running NTP automatically chooses as its time source the device with the lowest stratum number with which it communicates through NTP. This strategy effectively builds a self-organizing tree of NTP speakers.

NTP avoids synchronizing to a device whose time might not be accurate by never synchronizing to a device that is not synchronized. NTP also compares the time reported by several devices and does not synchronize to a device whose time is significantly different than the others, even if its stratum is lower.

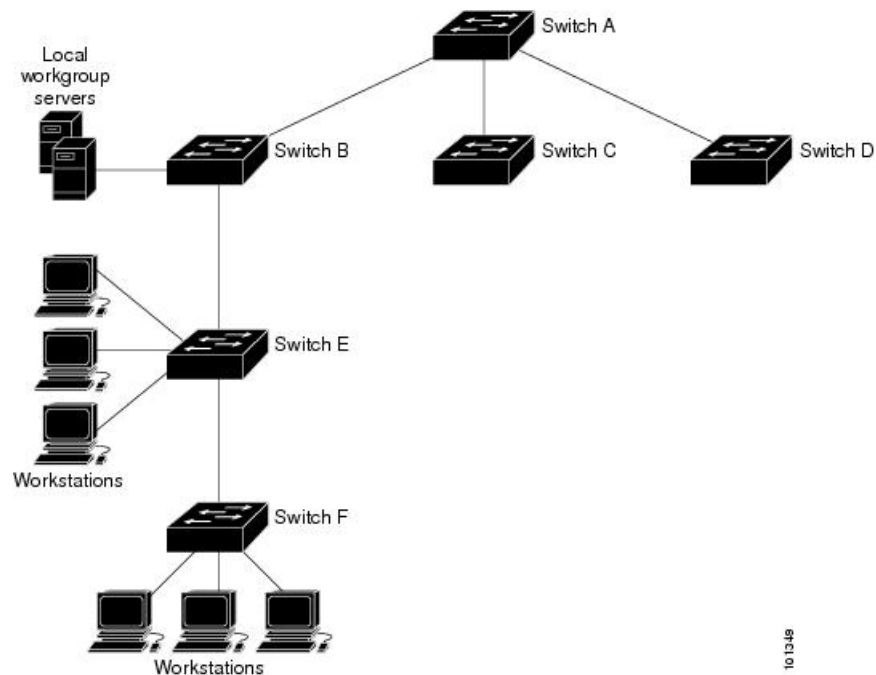
The communications between devices running NTP (known as associations) are usually statically configured; each device is given the IP address of all devices with which it should form associations. Accurate timekeeping is possible by exchanging NTP messages between each pair of devices with an association. However, in a LAN environment, NTP can be configured to use IP broadcast messages instead. This alternative reduces configuration complexity because each device can simply be configured to send or receive broadcast messages. However, in that case, information flow is one-way only.

The time kept on a device is a critical resource; you should use the security features of NTP to avoid the accidental or malicious setting of an incorrect time. Two mechanisms are available: an access list-based restriction scheme and an encrypted authentication mechanism.

Cisco's implementation of NTP does not support stratum 1 service; it is not possible to connect to a radio or atomic clock. We recommend that the time service for your network be derived from the public NTP servers available on the IP Internet.

The figure below shows a typical network example using NTP. Device A is the NTP master, with the Device B, C, and D configured in NTP server mode, in server association with Device A. Device E is configured as an NTP peer to the upstream and downstream Device, Device B and Device F, respectively.

**Figure 142: Typical NTP Network Configuration**



If the network is isolated from the Internet, Cisco's implementation of NTP allows a device to act as if it is synchronized through NTP, when in fact it has learned the time by using other means. Other devices then synchronize to that device through NTP.

When multiple sources of time are available, NTP is always considered to be more authoritative. NTP time overrides the time set by any other method.

Several manufacturers include NTP software for their host systems, and a publicly available version for systems running UNIX and its various derivatives is also available. This software allows host systems to be time-synchronized as well.

## NTP Stratum

NTP uses the concept of a *stratum* to describe how many NTP hops away a device is from an authoritative time source. A stratum 1 time server has a radio or atomic clock directly attached, a stratum 2 time server receives its time through NTP from a stratum 1 time server, and so on. A device running NTP automatically chooses as its time source the device with the lowest stratum number with which it communicates through NTP. This strategy effectively builds a self-organizing tree of NTP speakers.

NTP avoids synchronizing to a device whose time might not be accurate by never synchronizing to a device that is not synchronized. NTP also compares the time reported by several devices and does not synchronize to a device whose time is significantly different than the others, even if its stratum is lower.

## NTP Associations

The communications between devices running NTP (known as *associations*) are usually statically configured; each device is given the IP address of all devices with which it should form associations. Accurate timekeeping is possible by exchanging NTP messages between each pair of devices with an association. However, in a LAN environment, NTP can be configured to use IP broadcast messages instead. This alternative reduces configuration complexity because each device can simply be configured to send or receive broadcast messages. However, in that case, information flow is one-way only.

## NTP Security

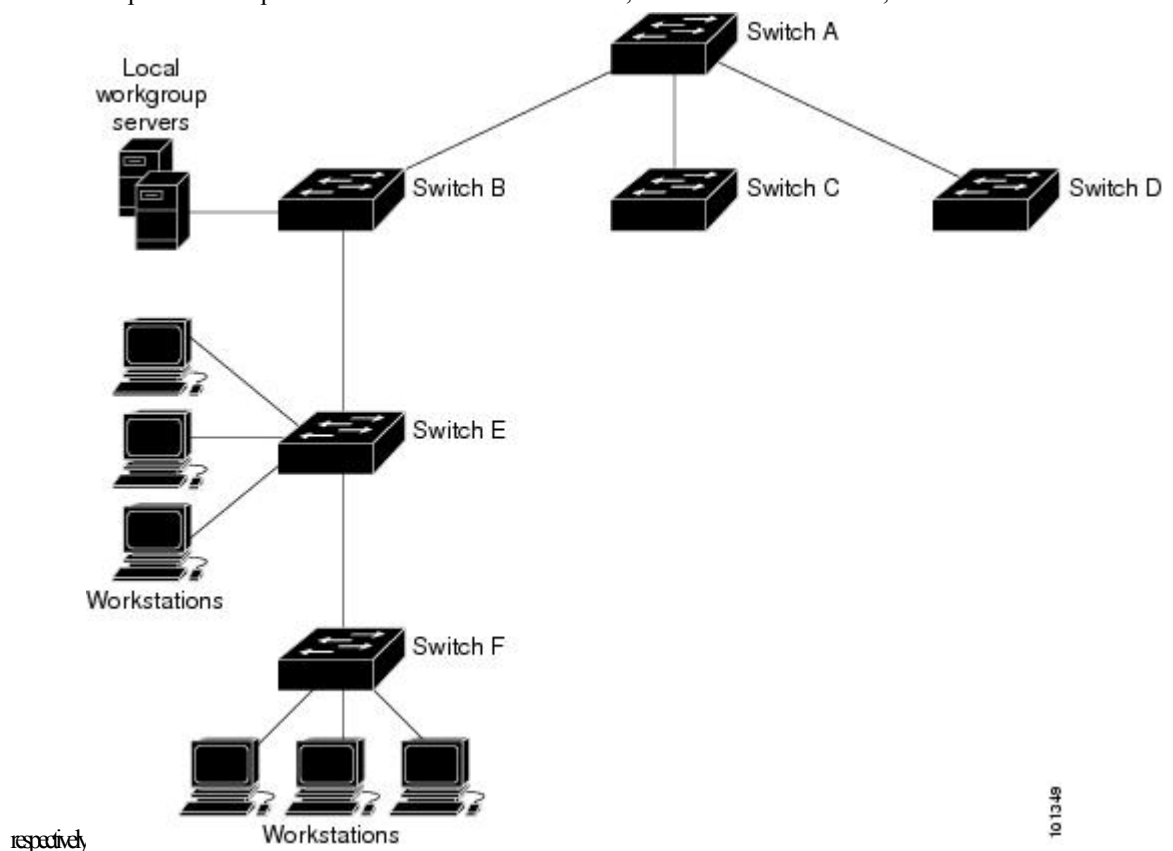
The time kept on a device is a critical resource; you should use the security features of NTP to avoid the accidental or malicious setting of an incorrect time. Two mechanisms are available: an access list-based restriction scheme and an encrypted authentication mechanism.

## NTP Implementation

Implementation of NTP does not support stratum 1 service; it is not possible to connect to a radio or atomic clock. We recommend that the time service for your network be derived from the public NTP servers available on the IP Internet.

**Figure 143: Typical NTP Network Configuration**

The following figure shows a typical network example using NTP. Switch A is the NTP master, with the Switch B, C, and D configured in NTP server mode, in server association with Switch A. Switch E is configured as an NTP peer to the upstream and downstream switches, Switch B and Switch F,



If the network is isolated from the Internet, NTP allows a device to act as if it is synchronized through NTP, when in fact it has learned the time by using other means. Other devices then synchronize to that device through NTP.

When multiple sources of time are available, NTP is always considered to be more authoritative. NTP time overrides the time set by any other method.

Several manufacturers include NTP software for their host systems, and a publicly available version for systems running UNIX and its various derivatives is also available. This software allows host systems to be time-synchronized as well.

## NTP Version 4

NTP version 4 is implemented on the device. NTPv4 is an extension of NTP version 3. NTPv4 supports both IPv4 and IPv6 and is backward-compatible with NTPv3.

NTPv4 provides these capabilities:

- Support for IPv6.
- Improved security compared to NTPv3. The NTPv4 protocol provides a security framework based on public key cryptography and standard X509 certificates.
- Automatic calculation of the time-distribution hierarchy for a network. Using specific multicast groups, NTPv4 automatically configures the hierarchy of the servers to achieve the best time accuracy for the lowest bandwidth cost. This feature leverages site-local IPv6 multicast addresses.

For details about configuring NTPv4, see the *Implementing NTPv4 in IPv6* chapter of the *Cisco IOS IPv6 Configuration Guide, Release 12.4T*.

## System Name and Prompt

You configure the system name on the Device to identify it. By default, the system name and prompt are *Switch*.

If you have not configured a system prompt, the first 20 characters of the system name are used as the system prompt. A greater-than symbol [*>*] is appended. The prompt is updated whenever the system name changes.

For complete syntax and usage information for the commands used in this section, see the *Cisco IOS Configuration Fundamentals Command Reference, Release 12.4* and the *Cisco IOS IP Command Reference, Volume 2 of 3: Routing Protocols, Release 12.4*.

## Stack System Name and Prompt

If you are accessing a stack member through the active switch, you must use the **session** *stack-member-number* privileged EXEC command. The stack member number range is from 1 through 4. When you use this command, the stack member number is appended to the system prompt. For example, *Switch-2#* is the prompt in privileged EXEC mode for stack member 2, and the system prompt for the switch stack is *Switch*.

## Default System Name and Prompt Configuration

The default switch system name and prompt is *Switch*.

## DNS

The DNS protocol controls the Domain Name System (DNS), a distributed database with which you can map hostnames to IP addresses. When you configure DNS on your device, you can substitute the hostname for the IP address with all IP commands, such as **ping**, **telnet**, **connect**, and related Telnet support operations.

IP defines a hierarchical naming scheme that allows a device to be identified by its location or domain. Domain names are pieced together with periods (.) as the delimiting characters. For example, Cisco Systems is a commercial organization that IP identifies by a *com* domain name, so its domain name is *cisco.com*. A specific device in this domain, for example, the File Transfer Protocol (FTP) system is identified as *ftp.cisco.com*.

To keep track of domain names, IP has defined the concept of a domain name server, which holds a cache (or database) of names mapped to IP addresses. To map domain names to IP addresses, you must first identify the hostnames, specify the name server that is present on your network, and enable the DNS.

### Default DNS Settings

*Table 186: Default DNS Settings*

| Feature                 | Default Setting                          |
|-------------------------|------------------------------------------|
| DNS enable state        | Enabled.                                 |
| DNS default domain name | None configured.                         |
| DNS servers             | No name server addresses are configured. |

## Login Banners

You can configure a message-of-the-day (MOTD) and a login banner. The MOTD banner is displayed on all connected terminals at login and is useful for sending messages that affect all network users (such as impending system shutdowns).

The login banner is also displayed on all connected terminals. It appears after the MOTD banner and before the login prompts.




---

**Note** For complete syntax and usage information for the commands used in this section, see the *Cisco IOS Configuration Fundamentals Command Reference, Release 12.4*.

---

### Default Banner Configuration

The MOTD and login banners are not configured.

## MAC Address Table

The MAC address table contains address information that the device uses to forward traffic between ports. All MAC addresses in the address table are associated with one or more ports. The address table includes these types of addresses:

- Dynamic address—A source MAC address that the device learns and then ages when it is not in use.

- Static address—A manually entered unicast address that does not age and that is not lost when the device resets.

The address table lists the destination MAC address, the associated VLAN ID, and port number associated with the address and the type (static or dynamic).



---

**Note** For complete syntax and usage information for the commands used in this section, see the command reference for this release.

---

## MAC Address Table Creation

With multiple MAC addresses supported on all ports, you can connect any port on the device to other network devices. The device provides dynamic addressing by learning the source address of packets it receives on each port and adding the address and its associated port number to the address table. As devices are added or removed from the network, the device updates the address table, adding new dynamic addresses and aging out those that are not in use.

The aging interval is globally configured. However, the device maintains an address table for each VLAN, and STP can accelerate the aging interval on a per-VLAN basis.

The device sends packets between any combination of ports, based on the destination address of the received packet. Using the MAC address table, the device forwards the packet only to the port associated with the destination address. If the destination address is on the port that sent the packet, the packet is filtered and not forwarded. The device always uses the store-and-forward method: complete packets are stored and checked for errors before transmission.

## MAC Addresses and VLANs

All addresses are associated with a VLAN. An address can exist in more than one VLAN and have different destinations in each. Unicast addresses, for example, could be forwarded to port 1 in VLAN 1 and ports 9, 10, and 1 in VLAN 5.

Each VLAN maintains its own logical address table. A known address in one VLAN is unknown in another until it is learned or statically associated with a port in the other VLAN.

## MAC Addresses and Device Stacks

The MAC address tables on all stack members are synchronized. At any given time, each stack member has the same copy of the address tables for each VLAN. When an address ages out, the address is removed from the address tables on all stack members. When a Device joins a switch stack, that Device receives the addresses for each VLAN learned on the other stack members. When a stack member leaves the switch stack, the remaining stack members age out or remove all addresses learned by the former stack member.

## Default MAC Address Table Settings

The following table shows the default settings for the MAC address table.

**Table 187: Default Settings for the MAC Address**

| Feature           | Default Setting       |
|-------------------|-----------------------|
| Aging time        | 300 seconds           |
| Dynamic addresses | Automatically learned |
| Static addresses  | None configured       |

## ARP Table Management

To communicate with a device (over Ethernet, for example), the software first must learn the 48-bit MAC address or the local data link address of that device. The process of learning the local data link address from an IP address is called *address resolution*.

The Address Resolution Protocol (ARP) associates a host IP address with the corresponding media or MAC addresses and the VLAN ID. Using an IP address, ARP finds the associated MAC address. When a MAC address is found, the IP-MAC address association is stored in an ARP cache for rapid retrieval. Then the IP datagram is encapsulated in a link-layer frame and sent over the network. Encapsulation of IP datagrams and ARP requests and replies on IEEE 802 networks other than Ethernet is specified by the Subnetwork Access Protocol (SNAP). By default, standard Ethernet-style ARP encapsulation (represented by the **arpa** keyword) is enabled on the IP interface.

ARP entries added manually to the table do not age and must be manually removed.

For CLI procedures, see the Cisco IOS Release 12.4 documentation on *Cisco.com*.

## How to Administer the Device

### Configuring the Time and Date Manually

System time remains accurate through restarts and reboot, however, you can manually configure the time and date after the system is restarted.

We recommend that you use manual configuration only when necessary. If you have an outside source to which the device can synchronize, you do not need to manually set the system clock.

### Setting the System Clock

If you have an outside source on the network that provides time services, such as an NTP server, you do not need to manually set the system clock.

Follow these steps to set the system clock:



**Procedure**

|               | Command or Action                                                                                                                                                                                                                                           | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br>Device> <b>enable</b>                                                                                                                                                                                                   | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>                                                                                                                                                                                                                                                                                                                            |
| <b>Step 2</b> | Use one of the following: <ul style="list-style-type: none"> <li>• <b>clock set</b> <i>hh:mm:ss day month year</i></li> <li>• <b>clock set</b> <i>hh:mm:ss month day year</i></li> </ul> <b>Example:</b><br>Device# <b>clock set 13:32:00 23 March 2013</b> | Manually set the system clock using one of these formats: <ul style="list-style-type: none"> <li>• <i>hh:mm:ss</i>—Specifies the time in hours (24-hour format), minutes, and seconds. The time specified is relative to the configured time zone.</li> <li>• <i>day</i>—Specifies the day by date in the month.</li> <li>• <i>month</i>—Specifies the month by name.</li> <li>• <i>year</i>—Specifies the year (no abbreviation).</li> </ul> |

**Configuring the Time Zone**

Follow these steps to manually configure the time zone:

**Procedure**

|               | Command or Action                                                                                                                        | Purpose                                                                                                                                                                    |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br>Device> <b>enable</b>                                                                                | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>                                                         |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                        | Enters global configuration mode.                                                                                                                                          |
| <b>Step 3</b> | <b>clock timezone zone hours-offset</b><br><i>[minutes-offset]</i><br><b>Example:</b><br>Device(config)# <b>clock timezone AST -3 30</b> | Sets the time zone.<br><br>Internal time is kept in Coordinated Universal Time (UTC), so this command is used only for display purposes and when the time is manually set. |

|               | Command or Action                                                                                                 | Purpose                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------|-------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               |                                                                                                                   | <ul style="list-style-type: none"> <li>• <i>zone</i>—Enters the name of the time zone to be displayed when standard time is in effect. The default is UTC.</li> <li>• <i>hours-offset</i>—Enters the hours offset from UTC.</li> <li>• (Optional) <i>minutes-offset</i>—Enters the minutes offset from UTC. This available where the local time zone is a percentage of an hour different from UTC.</li> </ul> |
| <b>Step 4</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b>                                                       | Returns to privileged EXEC mode.                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Step 5</b> | <b>show running-config</b><br><b>Example:</b><br>Device# <b>show running-config</b>                               | Verifies your entries.                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Step 6</b> | <b>copy running-config startup-config</b><br><b>Example:</b><br>Device# <b>copy running-config startup-config</b> | (Optional) Saves your entries in the configuration file.                                                                                                                                                                                                                                                                                                                                                       |

## Configuring Summer Time (Daylight Saving Time)

To configure summer time (daylight saving time) in areas where it starts and ends on a particular day of the week each year, perform this task:

### Procedure

|               | Command or Action                                         | Purpose                                                                                                            |
|---------------|-----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br>Device> <b>enable</b> | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul> |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b>              | Enters global configuration mode.                                                                                  |

|               | Command or Action                                                                                                                                                                                                             | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | Device# <code>configure terminal</code>                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Step 3</b> | <p><b>clock summer-time zone date date month year hh:mm date month year hh:mm [offset]</b></p> <p><b>Example:</b></p> <pre>Device(config)# clock summer-time PDT date 10 March 2013 2:00 3 November 2013 2:00</pre>           | Configures summer time to start and end on specified days every year.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Step 4</b> | <p><b>clock summer-time zone recurring [week day month hh:mm week day month hh:mm [offset]]</b></p> <p><b>Example:</b></p> <pre>Device(config)# clock summer-time PDT recurring 10 March 2013 2:00 3 November 2013 2:00</pre> | <p>Configures summer time to start and end on the specified days every year. All times are relative to the local time zone. The start time is relative to standard time.</p> <p>The end time is relative to summer time. Summer time is disabled by default. If you specify <b>clock summer-time zone recurring</b> without parameters, the summer time rules default to the United States rules.</p> <p>If the starting month is after the ending month, the system assumes that you are in the southern hemisphere.</p> <ul style="list-style-type: none"> <li>• <i>zone</i>—Specifies the name of the time zone (for example, PDT) to be displayed when summer time is in effect.</li> <li>• (Optional) <i>week</i>— Specifies the week of the month (1 to 4, <b>first</b>, or <b>last</b>).</li> <li>• (Optional) <i>day</i>—Specifies the day of the week (Sunday, Monday...).</li> <li>• (Optional) <i>month</i>—Specifies the month (January, February...).</li> <li>• (Optional) <i>hh:mm</i>—Specifies the time (24-hour format) in hours and minutes.</li> <li>• (Optional) <i>offset</i>—Specifies the number of minutes to add during summer time. The default is 60.</li> </ul> |
| <b>Step 5</b> | <p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>                                                                                                                                                       | Returns to privileged EXEC mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

|               | Command or Action                                                                                                       | Purpose                                                  |
|---------------|-------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| <b>Step 6</b> | <b>show running-config</b><br><b>Example:</b><br>Device# <code>show running-config</code>                               | Verifies your entries.                                   |
| <b>Step 7</b> | <b>copy running-config startup-config</b><br><b>Example:</b><br>Device# <code>copy running-config startup-config</code> | (Optional) Saves your entries in the configuration file. |

Follow these steps if summer time in your area does not follow a recurring pattern (configure the exact date and time of the next summer time events):

### Procedure

|               | Command or Action                                                                                                                                                                                               | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br>Device> <code>enable</code>                                                                                                                                                 | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <code>configure terminal</code>                                                                                                                         | Enters global configuration mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Step 3</b> | <b>clock summer-time zone date</b> [ <i>month date year hh:mm month date year hh:mm [offset]</i> ] <b>or</b> <b>clock summer-time zone date</b> [ <i>date month year hh:mm date month year hh:mm [offset]</i> ] | Configures summer time to start on the first date and end on the second date.<br>Summer time is disabled by default. <ul style="list-style-type: none"> <li>• For <i>zone</i>, specify the name of the time zone (for example, PDT) to be displayed when summer time is in effect.</li> <li>• (Optional) For <i>week</i>, specify the week of the month (1 to 5 or last).</li> <li>• (Optional) For <i>day</i>, specify the day of the week (Sunday, Monday...).</li> <li>• (Optional) For <i>month</i>, specify the month (January, February...).</li> <li>• (Optional) For <i>hh:mm</i>, specify the time (24-hour format) in hours and minutes.</li> </ul> |

|               | Command or Action                                                                                                 | Purpose                                                                                                                                                     |
|---------------|-------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               |                                                                                                                   | <ul style="list-style-type: none"> <li>(Optional) For <i>offset</i>, specify the number of minutes to add during summer time. The default is 60.</li> </ul> |
| <b>Step 4</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b>                                                       | Returns to privileged EXEC mode.                                                                                                                            |
| <b>Step 5</b> | <b>show running-config</b><br><b>Example:</b><br>Device# <b>show running-config</b>                               | Verifies your entries.                                                                                                                                      |
| <b>Step 6</b> | <b>copy running-config startup-config</b><br><b>Example:</b><br>Device# <b>copy running-config startup-config</b> | (Optional) Saves your entries in the configuration file.                                                                                                    |

## Configuring a System Name

Follow these steps to manually configure a system name:

### Procedure

|               | Command or Action                                                                 | Purpose                                                                                                                             |
|---------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br>Device> <b>enable</b>                         | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>                    |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b> | Enters global configuration mode.                                                                                                   |
| <b>Step 3</b> | <b>hostname <i>name</i></b><br><b>Example:</b><br>Device(config)# <b>hostname</b> | Configures a system name. When you set the system name, it is also used as the system prompt.<br><br>The default setting is Switch. |

|               | Command or Action                                                                                                       | Purpose                                                                                                                                                                                                               |
|---------------|-------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | <code>remote-users</code>                                                                                               | The name must follow the rules for ARPANET hostnames. They must start with a letter, end with a letter or digit, and have as interior characters only letters, digits, and hyphens. Names can be up to 63 characters. |
| <b>Step 4</b> | <b>end</b><br><b>Example:</b><br><code>remote-users(config)#end</code><br><code>remote-users#</code>                    | Returns to privileged EXEC mode.                                                                                                                                                                                      |
| <b>Step 5</b> | <b>show running-config</b><br><b>Example:</b><br><code>Device# show running-config</code>                               | Verifies your entries.                                                                                                                                                                                                |
| <b>Step 6</b> | <b>copy running-config startup-config</b><br><b>Example:</b><br><code>Device# copy running-config startup-config</code> | (Optional) Saves your entries in the configuration file.                                                                                                                                                              |

## Setting Up DNS

If you use the device IP address as its hostname, the IP address is used and no DNS query occurs. If you configure a hostname that contains no periods (.), a period followed by the default domain name is appended to the hostname before the DNS query is made to map the name to an IP address. The default domain name is the value set by the **ip domain-name** global configuration command. If there is a period (.) in the hostname, the Cisco IOS software looks up the IP address without appending any default domain name to the hostname.

Follow these steps to set up your switch to use the DNS:

### Procedure

|               | Command or Action                                                                       | Purpose                                                                                                            |
|---------------|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br><code>Device&gt; enable</code>                      | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul> |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b><br><code>Device# configure terminal</code> | Enters global configuration mode.                                                                                  |

|               | Command or Action                                                                                                                                                                                           | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 3</b> | <p><b>ip domain-name</b> <i>name</i></p> <p><b>Example:</b></p> <pre>Device(config)# ip domain-name Cisco.com</pre>                                                                                         | <p>Defines a default domain name that the software uses to complete unqualified hostnames (names without a dotted-decimal domain name).</p> <p>Do not include the initial period that separates an unqualified name from the domain name.</p> <p>At boot time, no domain name is configured; however, if the device configuration comes from a BOOTP or Dynamic Host Configuration Protocol (DHCP) server, then the default domain name might be set by the BOOTP or DHCP server (if the servers were configured with this information).</p> |
| <b>Step 4</b> | <p><b>ip name-server</b> <i>server-address1</i> [<i>server-address2 ... server-address6</i>]</p> <p><b>Example:</b></p> <pre>Device(config)# ip name-server 192.168.1.100 192.168.1.200 192.168.1.300</pre> | <p>Specifies the address of one or more name servers to use for name and address resolution.</p> <p>You can specify up to six name servers. Separate each server address with a space. The first server specified is the primary server. The device sends DNS queries to the primary server first. If that query fails, the backup servers are queried.</p>                                                                                                                                                                                  |
| <b>Step 5</b> | <p><b>ip domain-lookup</b> [<i>nsap</i>   <i>source-interface interface</i>]</p> <p><b>Example:</b></p> <pre>Device(config)# ip domain-lookup</pre>                                                         | <p>(Optional) Enables DNS-based hostname-to-address translation on your device. This feature is enabled by default.</p> <p>If your network devices require connectivity with devices in networks for which you do not control name assignment, you can dynamically assign device names that uniquely identify your devices by using the global Internet naming scheme (DNS).</p>                                                                                                                                                             |
| <b>Step 6</b> | <p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>                                                                                                                                     | <p>Returns to privileged EXEC mode.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Step 7</b> | <p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>                                                                                                             | <p>Verifies your entries.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Step 8</b> | <p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p>                                                                                                                                     | <p>(Optional) Saves your entries in the configuration file.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

|  | Command or Action                                       | Purpose |
|--|---------------------------------------------------------|---------|
|  | Device# <code>copy running-config startup-config</code> |         |

## Configuring a Message-of-the-Day Login Banner

You can create a single or multiline message banner that appears on the screen when someone logs in to the device.

Follow these steps to configure a MOTD login banner:

### Procedure

|               | Command or Action                                                                                                                                                                                                        | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                   |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br>Device> <code>enable</code>                                                                                                                                                          | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>                                                                                                                                                                                                                                                                                                        |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <code>configure terminal</code>                                                                                                                                  | Enters global configuration mode.                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Step 3</b> | <b>banner motd <i>c message c</i></b><br><b>Example:</b><br>Device(config)# <code>banner motd #</code><br>This is a secure site. Only<br>authorized users are allowed.<br>For access, contact technical<br>support.<br># | Specifies the message of the day.<br><i>c</i> —Enters the delimiting character of your choice, for example, a pound sign (#), and press the <b>Return</b> key. The delimiting character signifies the beginning and end of the banner text. Characters after the ending delimiter are discarded.<br><i>message</i> —Enters a banner message up to 255 characters. You cannot use the delimiting character in the message. |
| <b>Step 4</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <code>end</code>                                                                                                                                                        | Returns to privileged EXEC mode.                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Step 5</b> | <b>show running-config</b><br><b>Example:</b>                                                                                                                                                                            | Verifies your entries.                                                                                                                                                                                                                                                                                                                                                                                                    |



|               | Command or Action                                                                                                       | Purpose                                                  |
|---------------|-------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
|               | Device# <code>show running-config</code>                                                                                |                                                          |
| <b>Step 6</b> | <b>copy running-config startup-config</b><br><b>Example:</b><br>Device# <code>copy running-config startup-config</code> | (Optional) Saves your entries in the configuration file. |

## Configuring a Login Banner

You can configure a login banner to be displayed on all connected terminals. This banner appears after the MOTD banner and before the login prompt.

Follow these steps to configure a login banner:

### Procedure

|               | Command or Action                                                                                                                                                                         | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                    |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br>Device> <code>enable</code>                                                                                                                           | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>                                                                                                                                                                                                                                                                                                         |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <code>configure terminal</code>                                                                                                   | Enters global configuration mode.                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Step 3</b> | <b>banner login c message c</b><br><b>Example:</b><br>Device(config)# <code>banner login \$</code><br>Access for authorized users only.<br>Please enter your username and password.<br>\$ | Specifies the login message. <p><i>c</i>— Enters the delimiting character of your choice, for example, a pound sign (#), and press the <b>Return</b> key. The delimiting character signifies the beginning and end of the banner text. Characters after the ending delimiter are discarded.</p> <p><i>message</i>—Enters a login message up to 255 characters. You cannot use the delimiting character in the message.</p> |
| <b>Step 4</b> | <b>end</b><br><b>Example:</b>                                                                                                                                                             | Returns to privileged EXEC mode.                                                                                                                                                                                                                                                                                                                                                                                           |

|               | Command or Action                                                                                                       | Purpose                                                  |
|---------------|-------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
|               | <code>Device(config)# end</code>                                                                                        |                                                          |
| <b>Step 5</b> | <b>show running-config</b><br><b>Example:</b><br><code>Device# show running-config</code>                               | Verifies your entries.                                   |
| <b>Step 6</b> | <b>copy running-config startup-config</b><br><b>Example:</b><br><code>Device# copy running-config startup-config</code> | (Optional) Saves your entries in the configuration file. |

## Managing the MAC Address Table

### Changing the Address Aging Time

Follow these steps to configure the dynamic address table aging time:

#### Procedure

|               | Command or Action                                                                                                                                                                                                  | Purpose                                                                                                                                                                                                                                                                                                                                       |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br><code>Device&gt; enable</code>                                                                                                                                                 | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>                                                                                                                                                                                                                            |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b><br><code>Device# configure terminal</code>                                                                                                                            | Enters global configuration mode.                                                                                                                                                                                                                                                                                                             |
| <b>Step 3</b> | <b>mac address-table aging-time</b> [ <i>0</i>   <i>10-1000000</i> ] [ <b>routed-mac</b>   <b>vlan</b> <i>vlan-id</i> ]<br><b>Example:</b><br><code>Device(config)# mac address-table aging-time 500 vlan 2</code> | Sets the length of time that a dynamic entry remains in the MAC address table after the entry is used or updated.<br><br>The range is 10 to 1000000 seconds. The default is 300. You can also enter 0, which disables aging. Static address entries are never aged or removed from the table.<br><br><i>vlan-id</i> —Valid IDs are 1 to 4094. |

|               | Command or Action                                                                                                     | Purpose                                                  |
|---------------|-----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| <b>Step 4</b> | <b>end</b><br><b>Example:</b><br><pre>Device(config)# end</pre>                                                       | Returns to privileged EXEC mode.                         |
| <b>Step 5</b> | <b>show running-config</b><br><b>Example:</b><br><pre>Device# show running-config</pre>                               | Verifies your entries.                                   |
| <b>Step 6</b> | <b>copy running-config startup-config</b><br><b>Example:</b><br><pre>Device# copy running-config startup-config</pre> | (Optional) Saves your entries in the configuration file. |

## Configuring MAC Address Change Notification Traps

Follow these steps to configure the switch to send MAC address change notification traps to an NMS host:

### Procedure

|               | Command or Action                                                                                                                                                                                                                                                                                                                        | Purpose                                                                                                                                                                                                                                                                                   |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br><pre>Device&gt; enable</pre>                                                                                                                                                                                                                                                                         | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>                                                                                                                                                                        |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b><br><pre>Device# configure terminal</pre>                                                                                                                                                                                                                                                    | Enters global configuration mode.                                                                                                                                                                                                                                                         |
| <b>Step 3</b> | <b>snmp-server host <i>host-addr</i> <i>community-string</i> <i>notification-type</i> { <b>informs</b>   <b>traps</b> } { <b>version</b> { <b>1</b>   <b>2c</b>   <b>3</b> } } { <b>vrf</b> <i>vrf instance name</i> }</b><br><b>Example:</b><br><pre>Device(config)# snmp-server host 172.20.10.10 traps private mac-notification</pre> | Specifies the recipient of the trap message. <ul style="list-style-type: none"> <li>• <i>host-addr</i>—Specifies the name or address of the NMS.</li> <li>• <b>traps</b> (the default)—Sends SNMP traps to the host.</li> <li>• <b>informs</b>—Sends SNMP informs to the host.</li> </ul> |

|               | Command or Action                                                                                                                                                                                                                                                     | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               |                                                                                                                                                                                                                                                                       | <ul style="list-style-type: none"> <li>• <b>version</b>—Specifies the SNMP version to support. Version 1, the default, is not available with informs.</li> <li>• <b>community-string</b>—Specifies the string to send with the notification operation. Though you can set this string by using the <b>snmp-server host</b> command, we recommend that you define this string by using the <b>snmp-server community</b> command before using the <b>snmp-server host</b> command.</li> <li>• <b>notification-type</b>—Uses the <b>mac-notification</b> keyword.</li> <li>• <b>vrf vrf instance name</b>—Specifies the VPN routing/forwarding instance for this host.</li> </ul> |
| <b>Step 4</b> | <b>snmp-server enable traps mac-notification change</b><br><br><b>Example:</b><br><br><pre>Device(config)# snmp-server enable traps mac-notification change</pre>                                                                                                     | Enables the device to send MAC address change notification traps to the NMS.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Step 5</b> | <b>mac address-table notification change</b><br><br><b>Example:</b><br><br><pre>Device(config)# mac address-table notification change</pre>                                                                                                                           | Enables the MAC address change notification feature.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Step 6</b> | <b>mac address-table notification change [interval value] [history-size value]</b><br><br><b>Example:</b><br><br><pre>Device(config)# mac address-table notification change interval 123 Device(config)# mac address-table notification change history-size 100</pre> | <p>Enters the trap interval time and the history table size.</p> <ul style="list-style-type: none"> <li>• (Optional) <b>interval value</b>—Specifies the notification trap interval in seconds between each set of traps that are generated to the NMS. The range is 0 to 2147483647 seconds; the default is 1 second.</li> <li>• (Optional) <b>history-size value</b>—Specifies the maximum number of entries in the MAC notification history table. The range is 0 to 500; the default is 1.</li> </ul>                                                                                                                                                                      |
| <b>Step 7</b> | <b>interface interface-id</b><br><br><b>Example:</b>                                                                                                                                                                                                                  | Enters interface configuration mode, and specifies the Layer 2 interface on which to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

|                | Command or Action                                                                                                                                          | Purpose                                                                                                                                                                                                                                                                             |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | Device(config)# <b>interface</b><br><b>gigabitethernet 1/0/2</b>                                                                                           | enable the SNMP MAC address notification trap.                                                                                                                                                                                                                                      |
| <b>Step 8</b>  | <b>snmp trap mac-notification change {added   removed}</b><br><br><b>Example:</b><br><br>Device(config-if)# <b>snmp trap mac-notification change added</b> | Enables the MAC address change notification trap on the interface. <ul style="list-style-type: none"> <li>• Enables the trap when a MAC address is <b>added</b> on this interface.</li> <li>• Enables the trap when a MAC address is <b>removed</b> from this interface.</li> </ul> |
| <b>Step 9</b>  | <b>end</b><br><br><b>Example:</b><br><br>Device(config)# <b>end</b>                                                                                        | Returns to privileged EXEC mode.                                                                                                                                                                                                                                                    |
| <b>Step 10</b> | <b>show running-config</b><br><br><b>Example:</b><br><br>Device# <b>show running-config</b>                                                                | Verifies your entries.                                                                                                                                                                                                                                                              |
| <b>Step 11</b> | <b>copy running-config startup-config</b><br><br><b>Example:</b><br><br>Device# <b>copy running-config startup-config</b>                                  | (Optional) Saves your entries in the configuration file.                                                                                                                                                                                                                            |

## Configuring MAC Address Move Notification Traps

When you configure MAC-move notification, an SNMP notification is generated and sent to the network management system whenever a MAC address moves from one port to another within the same VLAN.

Follow these steps to configure the device to send MAC address-move notification traps to an NMS host:

### Procedure

|               | Command or Action                                                 | Purpose                                                                                                            |
|---------------|-------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><br><b>Example:</b><br><br>Device> <b>enable</b> | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul> |
| <b>Step 2</b> | <b>configure terminal</b><br><br><b>Example:</b>                  | Enters global configuration mode.                                                                                  |

|               | Command or Action                                                                                                                                                                                                                                                                                   | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | Device# <code>configure terminal</code>                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Step 3</b> | <p><b>snmp-server host</b> <i>host-addr</i> {<b>traps</b>   <b>informs</b>} {<b>version</b> {<b>1</b>   <b>2c</b>   <b>3</b>} } <i>community-string</i> <i>notification-type</i></p> <p><b>Example:</b></p> <pre>Device(config)# snmp-server host 172.20.10.10 traps private mac-notification</pre> | <p>Specifies the recipient of the trap message.</p> <ul style="list-style-type: none"> <li>• <i>host-addr</i>—Specifies the name or address of the NMS.</li> <li>• <b>traps</b> (the default)—Sends SNMP traps to the host.</li> <li>• <b>informs</b>—Sends SNMP informs to the host.</li> <li>• <b>version</b>—Specifies the SNMP version to support. Version 1, the default, is not available with informs.</li> <li>• <i>community-string</i>—Specifies the string to send with the notification operation. Though you can set this string by using the <b>snmp-server host</b> command, we recommend that you define this string by using the <b>snmp-server community</b> command before using the <b>snmp-server host</b> command.</li> <li>• <i>notification-type</i>—Uses the <b>mac-notification</b> keyword.</li> </ul> |
| <b>Step 4</b> | <p><b>snmp-server enable traps mac-notification move</b></p> <p><b>Example:</b></p> <pre>Device(config)# snmp-server enable traps mac-notification move</pre>                                                                                                                                       | Enables the device to send MAC address move notification traps to the NMS.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Step 5</b> | <p><b>mac address-table notification mac-move</b></p> <p><b>Example:</b></p> <pre>Device(config)# mac address-table notification mac-move</pre>                                                                                                                                                     | Enables the MAC address move notification feature.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Step 6</b> | <p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>                                                                                                                                                                                                                             | Returns to privileged EXEC mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

|               | Command or Action                                                                                                       | Purpose                                                  |
|---------------|-------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| <b>Step 7</b> | <b>show running-config</b><br><b>Example:</b><br>Device# <code>show running-config</code>                               | Verifies your entries.                                   |
| <b>Step 8</b> | <b>copy running-config startup-config</b><br><b>Example:</b><br>Device# <code>copy running-config startup-config</code> | (Optional) Saves your entries in the configuration file. |

### What to do next

To disable MAC address-move notification traps, use the **no snmp-server enable traps mac-notification move** global configuration command. To disable the MAC address-move notification feature, use the **no mac address-table notification mac-move** global configuration command.

You can verify your settings by entering the **show mac address-table notification mac-move** privileged EXEC commands.

## Configuring MAC Threshold Notification Traps

When you configure MAC threshold notification, an SNMP notification is generated and sent to the network management system when a MAC address table threshold limit is reached or exceeded.

Follow these steps to configure the switch to send MAC address table threshold notification traps to an NMS host:

### Procedure

|               | Command or Action                                                                                                                              | Purpose                                                                                                                                                     |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br>Device> <code>enable</code>                                                                                | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>                                          |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <code>configure terminal</code>                                                        | Enters global configuration mode.                                                                                                                           |
| <b>Step 3</b> | <b>snmp-server host <i>host-addr</i> {traps   informs} {version {1   2c   3}} <i>community-string notification-type</i></b><br><b>Example:</b> | Specifies the recipient of the trap message. <ul style="list-style-type: none"> <li>• <i>host-addr</i>—Specifies the name or address of the NMS.</li> </ul> |

|               | Command or Action                                                                                                                                                                                                                                                     | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | <pre>Device(config)# snmp-server host 172.20.10.10 traps private mac-notification</pre>                                                                                                                                                                               | <ul style="list-style-type: none"> <li>• <b>traps</b> (the default)—Sends SNMP traps to the host.</li> <li>• <b>informs</b>—Sends SNMP informs to the host.</li> <li>• <b>version</b>—Specifies the SNMP version to support. Version 1, the default, is not available with informs.</li> <li>• <i>community-string</i>—Specifies the string to send with the notification operation. You can set this string by using the <b>snmp-server host</b> command, but we recommend that you define this string by using the <b>snmp-server community</b> command before using the <b>snmp-server host</b> command.</li> <li>• <i>notification-type</i>—Uses the <b>mac-notification</b> keyword.</li> </ul> |
| <b>Step 4</b> | <p><b>snmp-server enable traps mac-notification threshold</b></p> <p><b>Example:</b></p> <pre>Device(config)# snmp-server enable traps mac-notification threshold</pre>                                                                                               | Enables MAC threshold notification traps to the NMS.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Step 5</b> | <p><b>mac address-table notification threshold</b></p> <p><b>Example:</b></p> <pre>Device(config)# mac address-table notification threshold</pre>                                                                                                                     | Enables the MAC address threshold notification feature.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Step 6</b> | <p><b>mac address-table notification threshold [limit percentage]   [interval time]</b></p> <p><b>Example:</b></p> <pre>Device(config)# mac address-table notification threshold interval 123 Device(config)# mac address-table notification threshold limit 78</pre> | <p>Enters the threshold value for the MAC address threshold usage monitoring.</p> <ul style="list-style-type: none"> <li>• (Optional) <b>limit percentage</b>—Specifies the percentage of the MAC address table use; valid values are from 1 to 100 percent. The default is 50 percent.</li> <li>• (Optional) <b>interval time</b>—Specifies the time between notifications; valid values are greater than or equal to 120 seconds. The default is 120 seconds.</li> </ul>                                                                                                                                                                                                                           |



|               | Command or Action                                                                                                     | Purpose                                                  |
|---------------|-----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| <b>Step 7</b> | <b>end</b><br><b>Example:</b><br><br>Device(config)# <b>end</b>                                                       | Returns to privileged EXEC mode.                         |
| <b>Step 8</b> | <b>show running-config</b><br><b>Example:</b><br><br>Device# <b>show running-config</b>                               | Verifies your entries.                                   |
| <b>Step 9</b> | <b>copy running-config startup-config</b><br><b>Example:</b><br><br>Device# <b>copy running-config startup-config</b> | (Optional) Saves your entries in the configuration file. |

## Adding and Removing Static Address Entries

Follow these steps to add a static address:

### Procedure

|               | Command or Action                                                                                                                                                                                            | Purpose                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br><br>Device> <b>enable</b>                                                                                                                                                | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>                                                                                                                                                                                                                                                                                             |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b><br><br>Device# <b>configure terminal</b>                                                                                                                        | Enters global configuration mode.                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Step 3</b> | <b>mac address-table static mac-addr vlan vlan-id interface interface-id</b><br><b>Example:</b><br><br>Device(config)# <b>mac address-table static c2f3.220a.12f4 vlan 4 interface gigabitethernet 1/0/1</b> | Adds a static address to the MAC address table. <ul style="list-style-type: none"> <li>• <i>mac-addr</i>—Specifies the destination MAC unicast address to add to the address table. Packets with this destination address received in the specified VLAN are forwarded to the specified interface.</li> <li>• <i>vlan-id</i>—Specifies the VLAN for which the packet with the specified MAC address</li> </ul> |

|               | Command or Action                                                                                                             | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|---------------|-------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               |                                                                                                                               | <p>is received. Valid VLAN IDs are 1 to 4094.</p> <ul style="list-style-type: none"> <li>• <i>interface-id</i>—Specifies the interface to which the received packet is forwarded. Valid interfaces include physical ports or port channels. For static multicast addresses, you can enter multiple interface IDs. For static unicast addresses, you can enter only one interface at a time, but you can enter the command multiple times with the same MAC address and VLAN ID.</li> </ul> |
| <b>Step 4</b> | <p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>                                                       | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Step 5</b> | <p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>                               | Verifies your entries.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Step 6</b> | <p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre> | (Optional) Saves your entries in the configuration file.                                                                                                                                                                                                                                                                                                                                                                                                                                   |

## Configuring Unicast MAC Address Filtering

Follow these steps to configure the Device to drop a source or destination unicast static address:

### Procedure

|               | Command or Action                                                                             | Purpose                                                                                                                   |
|---------------|-----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>                      | <p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul> |
| <b>Step 2</b> | <p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre> | Enters global configuration mode.                                                                                         |

|               | Command or Action                                                                                                                                                             | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 3</b> | <b>mac address-table static <i>mac-addr</i> vlan <i>vlan-id</i> drop</b><br><b>Example:</b><br><pre>Device(config)# mac address-table static c2f3.220a.12f4 vlan 4 drop</pre> | Enables unicast MAC address filtering and configure the device to drop a packet with the specified source or destination unicast static address. <ul style="list-style-type: none"> <li>• <i>mac-addr</i>—Specifies a source or destination unicast MAC address (48-bit). Packets with this MAC address are dropped.</li> <li>• <i>vlan-id</i>—Specifies the VLAN for which the packet with the specified MAC address is received. Valid VLAN IDs are 1 to 4094.</li> </ul> |
| <b>Step 4</b> | <b>end</b><br><b>Example:</b><br><pre>Device(config)# end</pre>                                                                                                               | Returns to privileged EXEC mode.                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Step 5</b> | <b>show running-config</b><br><b>Example:</b><br><pre>Device# show running-config</pre>                                                                                       | Verifies your entries.                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Step 6</b> | <b>copy running-config startup-config</b><br><b>Example:</b><br><pre>Device# copy running-config startup-config</pre>                                                         | (Optional) Saves your entries in the configuration file.                                                                                                                                                                                                                                                                                                                                                                                                                    |

## Monitoring and Maintaining Administration of the Device

| Command                                                              | Purpose                                                               |
|----------------------------------------------------------------------|-----------------------------------------------------------------------|
| <b>clear mac address-table dynamic</b>                               | Removes all dynamic entries.                                          |
| <b>clear mac address-table dynamic address <i>mac-address</i></b>    | Removes a specific MAC address.                                       |
| <b>clear mac address-table dynamic interface <i>interface-id</i></b> | Removes all addresses on the specified physical port or port channel. |
| <b>clear mac address-table dynamic vlan <i>vlan-id</i></b>           | Removes all addresses on a specified VLAN.                            |
| <b>show clock [<i>detail</i>]</b>                                    | Displays the time and date configuration.                             |

| Command                                                                          | Purpose                                                                      |
|----------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| <code>show ip igmp snooping groups</code>                                        | Displays the Layer 2 multicast entries for all VLANs or the specified VLAN.  |
| <code>show mac address-table address <i>mac-address</i></code>                   | Displays MAC address table information for the specified MAC address.        |
| <code>show mac address-table aging-time</code>                                   | Displays the aging time in all VLANs or the specified VLAN.                  |
| <code>show mac address-table count</code>                                        | Displays the number of addresses present in all VLANs or the specified VLAN. |
| <code>show mac address-table dynamic</code>                                      | Displays only dynamic MAC address table entries.                             |
| <code>show mac address-table interface <i>interface-name</i></code>              | Displays the MAC address table information for the specified interface.      |
| <code>show mac address-table move update</code>                                  | Displays the MAC address table move update information.                      |
| <code>show mac address-table multicast</code>                                    | Displays a list of multicast MAC addresses.                                  |
| <code>show mac address-table notification {change   mac-move   threshold}</code> | Displays the MAC notification parameters and history table.                  |
| <code>show mac address-table secure</code>                                       | Displays the secure MAC addresses.                                           |
| <code>show mac address-table static</code>                                       | Displays only static MAC address table entries.                              |
| <code>show mac address-table vlan <i>vlan-id</i></code>                          | Displays the MAC address table information for the specified VLAN.           |

## Configuration Examples for Device Administration

### Example: Setting the System Clock

This example shows how to manually set the system clock:

```
Device# clock set 13:32:00 23 July 2013
```

### Examples: Configuring Summer Time

This example (for daylight savings time) shows how to specify that summer time starts on March 10 at 02:00 and ends on November 3 at 02:00:

```
Device(config)# clock summer-time PDT recurring PST date
```

```
10 March 2013 2:00 3 November 2013 2:00
```

This example shows how to set summer time start and end dates:

```
Device(config)#clock summer-time PST date
20 March 2013 2:00 20 November 2013 2:00
```

## Example: Configuring a MOTD Banner

This example shows how to configure a MOTD banner by using the pound sign (#) symbol as the beginning and ending delimiter:

```
Device(config)# banner motd #
This is a secure site. Only authorized users are allowed.
For access, contact technical support.
#
Device(config)#
```

This example shows the banner that appears from the previous configuration:

```
Unix> telnet 192.0.2.15
Trying 192.0.2.15...
Connected to 192.0.2.15.
Escape character is '^]'.
This is a secure site. Only authorized users are allowed.
For access, contact technical support.
User Access Verification
Password:
```

## Example: Configuring a Login Banner

This example shows how to configure a login banner by using the dollar sign (\$) symbol as the beginning and ending delimiter:

```
Device(config)# banner login $
Access for authorized users only. Please enter your username and password.
$
Device(config)#
```

## Example: Configuring MAC Address Change Notification Traps

This example shows how to specify 172.20.10.10 as the NMS, enable MAC address notification traps to the NMS, enable the MAC address-change notification feature, set the interval time to 123 seconds, set the history-size to 100 entries, and enable traps whenever a MAC address is added on the specified port:

```
Device(config)# snmp-server host 172.20.10.10 traps private mac-notification
Device(config)# snmp-server enable traps mac-notification change
Device(config)# mac address-table notification change
Device(config)# mac address-table notification change interval 123
Device(config)# mac address-table notification change history-size 100
Device(config)# interface gigabitethernet 1/2/1
Device(config-if)# snmp trap mac-notification change added
```

## Example: Configuring MAC Threshold Notification Traps

This example shows how to specify 172.20.10.10 as the NMS, enable the MAC address threshold notification feature, set the interval time to 123 seconds, and set the limit to 78 per cent:

```
Device(config)# snmp-server host 172.20.10.10 traps private mac-notification
Device(config)# snmp-server enable traps mac-notification threshold
Device(config)# mac address-table notification threshold
Device(config)# mac address-table notification threshold interval 123
Device(config)# mac address-table notification threshold limit 78
```

## Example: Adding the Static Address to the MAC Address Table

This example shows how to add the static address c2f3.220a.12f4 to the MAC address table. When a packet is received in VLAN 4 with this MAC address as its destination address, the packet is forwarded to the specified port:



**Note** You cannot associate the same static MAC address to multiple interfaces. If the command is executed again with a different interface, the static MAC address is overwritten on the new interface.

```
Device(config)# mac address-table static c2f3.220a.12f4 vlan 4 interface gigabitethernet
1/1/1
```

## Example: Configuring Unicast MAC Address Filtering

This example shows how to enable unicast MAC address filtering and how to configure drop packets that have a source or destination address of c2f3.220a.12f4. When a packet is received in VLAN 4 with this MAC address as its source or destination, the packet is dropped:

```
Device(config)# mac address-table static c2f3.220a.12f4 vlan 4 drop
```

# Additional References for Device Administration

## Related Documents

| Related Topic                                  | Document Title                                                                                                                                                                                                    |
|------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| System management commands                     | <i>System Management Command Reference (Catalyst 3850 Switches)</i>                                                                                                                                               |
| Network management configuration               | <i>Network Management Configuration Guide (Catalyst 3850 Switches)</i>                                                                                                                                            |
| Layer 2 configuration                          | <i>Layer 2/3 Configuration Guide (Catalyst 3850 Switches)</i>                                                                                                                                                     |
| VLAN configuration                             | <i>VLAN Configuration Guide (Catalyst 3850 Switches)</i>                                                                                                                                                          |
| Platform-independent command references        | <i>Configuration Fundamentals Command Reference, Cisco IOS XE Release 3S (Catalyst 3850 Switches)</i>                                                                                                             |
| Platform-independent configuration information | <i>Configuration Fundamentals Configuration Guide, Cisco IOS XE Release 3S (Catalyst 3850 Switches)</i><br><br><i>IP Addressing Configuration Guide Library, Cisco IOS XE Release 3S (Catalyst 3850 Switches)</i> |

## Standards and RFCs

| Standard/RFC | Title |
|--------------|-------|
| None         | —     |

## MIBs

| MIB                                  | MIBs Link                                                                                                                                                                                                                  |
|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| All supported MIBs for this release. | To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:<br><br><a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a> |

**Technical Assistance**

| Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Link                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p> | <a href="http://www.cisco.com/support">http://www.cisco.com/support</a> |

## Additional References for Device Administration

**Related Documents**

| Related Topic                                  | Document Title                                                                                                                                                                                                    |
|------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| System management commands                     | <i>System Management Command Reference (Catalyst 3650 Switches)</i>                                                                                                                                               |
| Network management configuration               | <i>Network Management Configuration Guide (Catalyst 3650 Switches)</i>                                                                                                                                            |
| Layer 2 configuration                          | <i>Layer 2/3 Configuration Guide (Catalyst 3650 Switches)</i>                                                                                                                                                     |
| VLAN configuration                             | <i>VLAN Configuration Guide (Catalyst 3650 Switches)</i>                                                                                                                                                          |
| Platform-independent command references        | <i>Configuration Fundamentals Command Reference, Cisco IOS XE Release 3S (Catalyst 3650 Switches)</i>                                                                                                             |
| Platform-independent configuration information | <i>Configuration Fundamentals Configuration Guide, Cisco IOS XE Release 3S (Catalyst 3650 Switches)</i><br><br><i>IP Addressing Configuration Guide Library, Cisco IOS XE Release 3S (Catalyst 3650 Switches)</i> |



**Standards and RFCs**

| Standard/RFC | Title |
|--------------|-------|
| None         | —     |

**MIBs**

| MIB                                  | MIBs Link                                                                                                                                                                                                              |
|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| All supported MIBs for this release. | To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:<br><a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a> |

**Technical Assistance**

| Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Link                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p> | <a href="http://www.cisco.com/support">http://www.cisco.com/support</a> |

## Feature History and Information for Device Administration

| Release            | Modification                 |
|--------------------|------------------------------|
| Cisco IOS XE 3.2SE | This feature was introduced. |





## CHAPTER 128

# Boot Integrity Visibility

- [Finding Feature Information](#), on page 2397
- [Information About Boot Integrity Visibility](#), on page 2397
- [Verifying the software image and hardware](#), on page 2397
- [Verifying Platform Identity and Software Integrity](#), on page 2398

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Boot Integrity Visibility

Boot integrity visibility allows Cisco's platform identity and software integrity information to be visible and actionable. Platform identity provides the platform's manufacturing installed identity, and software integrity exposes boot integrity measurements that can be used to assess whether the platform has booted trusted code.

During the boot process, the software creates a checksum record of each stage of the boot loader activities.

You can retrieve this record and compare it with a Cisco-certified record to verify if your software image is genuine. If the checksum values do not match, you may be running a software image that is either not certified by Cisco or has been altered by an unauthorized party.

## Verifying the software image and hardware

This task describes how to retrieve the checksum record that was created during switch bootup. Enter the following commands in privileged EXEC mode.



**Note** On executing the following commands, you might see the message **% Please Try After Few Seconds** displayed on the CLI. This does not indicate a CLI failure, but indicates setting up of underlying infrastructure required to get the required output. It is recommended to wait for few minutes and then try the command again.

The messages **% Error retrieving SUDI certificate** and **% Error retrieving integrity data** signify a real CLI failure.

### Procedure

|               | Command or Action                                                                                                                                                             | Purpose                                                                                                                                                                                                     |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>show platform sudi certificate</b> [ <b>sign</b> [ <b>nonce</b> <i>nonce</i> ]]<br><br><b>Example:</b><br><br>Device# <b>show platform sudi certificate sign nonce 123</b> | Displays checksum record for the specific SUDI.<br><br><ul style="list-style-type: none"> <li>• (Optional) <b>sign</b> - Show signature</li> <li>• (Optional) <b>nonce</b> - Enter a nonce value</li> </ul> |
| <b>Step 2</b> | <b>show platform integrity</b> [ <b>sign</b> [ <b>nonce</b> <i>nonce</i> ]]<br><br><b>Example:</b><br><br>Device# <b>show platform integrity sign nonce 123</b>               | Displays checksum record for boot stages.<br><br><ul style="list-style-type: none"> <li>• (Optional) <b>sign</b> - Show signature</li> <li>• (Optional) <b>nonce</b> - Enter a nonce value</li> </ul>       |

## Verifying Platform Identity and Software Integrity

### Verifying Platform Identity

The following example displays the Secure Unique Device Identity (SUDI) chain in PEM format. The first certificate is the Cisco Root CA 2048 and the second is the Cisco subordinate CA (ACT2 SUDI CA). Both certificates can be verified to match those published on <https://www.cisco.com/security/pki/>. The third is the SUDI certificate.

```
Device#show platform sudi certificate sign nonce 123
```

```
-----BEGIN CERTIFICATE-----
MIIDQzCCAiuGAWIBAgIQX/h7KctU3I1CoxW1aMmt/zANBgkqhkiG9w0BAQUFADA1
MRYwFAYDVQQKEw1DaXNjbyBTeXN0ZW1zMRswGQYDVQQDEsJDaXNjbyBSb290IENB
IDIwNDgwHhcNMDQwNTE0MjAxNzEyWhcNMjkwNTE0MjAyNTQyWjA1MRYwFAYDVQQK
Ew1DaXNjbyBTeXN0ZW1zMRswGQYDVQQDEsJDaXNjbyBSb290IENBIDIwNDgwggEg
MA0GCSqGSIb3DQEBAQUAA4IBDQAwggEIAoIBAQCwmrmrp68Kd6ficba0ZmKueIhH
xmJVhEAYv8CrLqUccda8bnuoqrpu0hWISEWdovyD0My5jOAmahBKeN8hF570YQXJ
FcjPFto1YYmUQ6iEqdGYeJu5Tm8sUxJsZr2tKyS7McQr/4NEb7Y9JhcJ6r8qqB9q
VvYgDxFU14F1pyXOWWqCZe+36ufijXWlLvLdT6ZeYpzPEApk0E5tzivMW/VgpSdH
jWn0f84bcN5wGyDwbs2mAag8EtKpP6BrXruOIIt6ke01a06g58QBdKhTCytKmg9l
Eg6CTY5j/e/rmxxrbU6YTYK/CfdfHbBcl1HP7R2RQgYCUTOG/rksc35LtLgXfAgED
o1EwtzALBgNVHQ8EBAMCAYYWdwYDVR0TAQH/BAUwAwEB/zAdBgNVHQ4EFgQUJ/PI
```



```
3A74F2DBF293F52423ECB7B8539667080A9C57DA3E4B08B2B2CA623B2CBAF7080A0A
EB09B222E5B756970A3AA27E0F1D17C8A243
```

The optional RSA 2048 signature is across the three certificates, the signature version and the user-provided nonce

```
RSA PKCS#1v1.5 Sign {<Nonce (UINT64)> || <Signature Version (UINT32)> || <Cisco Root CA
2048 cert (DER)> ||
<Cisco subordinate CA (DER)> || <SUDI certificate (DER)> }
```

Cisco management solutions are equipped with the ability to interpret the above output. However, a simple script using OpenSSL commands can also be used to display the identity of the platform and to verify the signature, thereby ensuring its Cisco unique device identity.

```
[linux-host:~]openssl x509 -in sudicert.pem -subject -noout
subject= /serialNumber=PID:WS-C3650-12X48UQ SN:FDO1946BG05/O=Cisco/OU=ACT-2 Lite
SUDI/CN=WS-C3650-12X48UQ
```

### Verifying Software Integrity

The following example displays the checksum record for the boot stages. The hash measurements are displayed for each of the three stages of software successively booted. These hashes can be compared against Cisco-provided reference values. An option to sign the output gives a verifier the ability to ensure the output is genuine and is not altered. A nonce can be provided to protect against replay attacks.

```
Device #show platform integrity sign nonce 456
```

```
Platform: WS-C3650-12X48UQ
Boot Loader Version: CAT3K_CAA Boot Loader (CAT3K_CAA-HBOOT-M) Version 4.16, engineering
software (D)
Boot Loader Hash: DB5A686E9F4CE358481DE3AF8B9C762F0A604E3B4764DF2A351F176E3D7
D3C60EB85C02906BD8CF28228C0DFC2AA8960CAFE6675D696E4ABA0CD687C0609E7E2
Boot 0 Version: F01062R15.0508d68fa2015-09-15
Boot 0 Hash: 6EF15CD54D3C66A8B644194A67B7ED57044C8C2E0EECB69736A7FFEC1F6D0EAD
OS Version: 2016-10-18_10.57_mundru
OS Hash: 4C85AECC88DAA49D940BBF65B1F17269F55C8D98DEFB4140F981923AA961140293E1
3B3E6E68CE3F8ED7F596CD858ACDD4BEF6538F59C1E243C351353026E6CD
PCR0: 90214167AAF35C06B2AC97292596E5669EAB72578FCDAD0B91746683BAA7B2B0
PCR8: FC2CE1BAC397F97008936DF372A2218BB16A798222B8FF55A7B6AEDA8018EDF5
Signature version: 1
Signature:
632A724F1AB6ADE134F6B0E8724D2052B3157F45B47E547763EE224A848E807CD737600587FF68
2526A8FE354A116CC9EDEBD9C659B9927336542EE4295084368327D01BD22AB4849B3C007B6EB
B67708685FD6BC85DD045431E19A389FEB358894D4FBCF7C0FC960AC9133B61099DFD507F316C1
BF82F7F98687C7E7E8F99355DC1A95BD511B0B8DCB0CA909828F9EFBDF18847930392A8E3D072D
F3D90536880BAE9B7D7CF0E301D3F5AF16E7517FC2700E2F75911B836D6559A18E15B4CF452555
91656DF22DF73392F777AEB796BCF9AC046C581ADEF19CA48A98F620BB58A79B32DA8B3BFB1CF
8399468A096E2F0C54B8B3ECD15EE3FE2C5ABDB5A029
```

The optional RSA 2048 signature is produced with the SUDI private key and can be verified with the SUDI public key contained in the SUDI certificate. The signature across PCR values, the signature version and the user-provided nonce is displayed.

```
RSA PKCS# 1 v1.5 Sign { <Nonce (UINT64)> || <Signature Version (UINT32)> || <PCR0 (32 bytes)>
|| <PCR8 (32 bytes)> }
```

Cisco management solutions are equipped with the ability to interpret the above output, compare the results against published Cisco values, and to verify the signature.



## CHAPTER 129

# Performing Device Setup Configuration

- [Finding Feature Information, on page 2401](#)
- [Information About Performing Device Setup Configuration, on page 2401](#)
- [How to Perform Device Setup Configuration, on page 2413](#)
- [Monitoring Device Setup Configuration, on page 2428](#)
- [Configuration Examples for Performing Device Setup, on page 2432](#)
- [Additional References For Performing Device Setup, on page 2433](#)
- [Installing WCM Sub-Package, on page 2435](#)
- [Feature History and Information For Performing Device Setup Configuration, on page 2436](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Performing Device Setup Configuration

Review the sections in this module before performing your initial device configuration tasks that include IP address assignments and DHCP autoconfiguration.

## Device Boot Process

To start your device, you need to follow the procedures in the hardware installation guide for installing and powering on the device and setting up the initial device configuration (IP address, subnet mask, default gateway, secret and Telnet passwords, and so forth).

The normal boot process involves the operation of the boot loader software and includes these activities:

- Performs low-level CPU initialization. It initializes the CPU registers, which control where physical memory is mapped, its quantity, its speed, and so forth.

- Performs power-on self-test (POST) for the CPU subsystem and tests the system DRAM.
- Initializes the file systems on the system board.
- Loads a default operating system software image into memory and boots up the device.

The boot loader provides access to the file systems before the operating system is loaded. Normally, the boot loader is used only to load, decompress, and start the operating system. After the boot loader gives the operating system control of the CPU, the boot loader is not active until the next system reset or power-on.

The boot loader also provides trap-door access into the system if the operating system has problems serious enough that it cannot be used. The trap-door mechanism provides enough access to the system so that if it is necessary, you can reinstall the operating system software image by using the Xmodem Protocol, recover from a lost or forgotten password, and finally restart the operating system.

Before you can assign device information, make sure you have connected a PC or terminal to the console port or a PC to the Ethernet management port, and make sure you have configured the PC or terminal-emulation software baud rate and character format to match these of the device console port:

- Baud rate default is 9600.
- Data bits default is 8.




---

**Note** If the data bits option is set to 8, set the parity option to none.

---

- Stop bits default is 2 (minor).
- Parity settings default is none.

## Software Installer Features

The following software installer features are supported on your switch:

- Software bundle installation on a standalone switch, a switch stack, or a subset of switches in a stack. The default is installation on all the switches if a switch stack is configured.
- Software rollback to a previously installed package set.
- Emergency installation in the event that no valid installed packages reside on the boot flash.
- Auto-upgrade of a switch that joins the switch stack with incompatible software.
- Installation using packages on one switch as the source for installing packages on another switch in the switch stack.




---

**Note** Software installation and rollback must be performed while running only in installed mode. You can use the **request platform software package expand EXEC** command to convert bundle boot mode to install mode.

---



## Software Boot Modes

Your device supports two modes to boot the software packages:

- Installed mode
- Bundle mode

### Related Topics

[Examples: Displaying Software Bootup in Install Mode](#), on page 2428

[Example: Emergency Installation](#), on page 2430

## Installed Boot Mode

You can boot your device in installed mode by booting the software package provisioning file that resides in flash:

```
Switch: boot flash:packages.conf
```

The provisioning file contains a list of software packages to boot, mount, and run. The ISO file system in each installed package is mounted to the root file system directly from flash.



---

**Note** The packages and provisioning file used to boot in installed mode must reside in flash. Booting in installed mode from usbflash0: or tftp: is not supported.

---

### Related Topics

[Examples: Displaying Software Bootup in Install Mode](#), on page 2428

[Example: Emergency Installation](#), on page 2430

## Bundle Boot Mode

You can boot your device in bundle boot mode by booting the bundle (.bin) file:

```
switch: boot flash:cat3850-universalk9.SSA.03.08.83.EMD.150-8.83.EMD.bin
```

The provisioning file contained in a bundle is used to decide which packages to boot, mount, and run. Packages are extracted from the bundle and copied to RAM. The ISO file system in each package is mounted to the root file system.

Unlike install boot mode, additional memory that is equivalent to the size of the bundle is used when booting in bundle mode.

Unlike install boot mode, bundle boot mode is available from several locations:

- flash:
- usbflash0:
- tftp:



---

**Note** Auto install and smart install functionality is not supported in bundle boot mode.

---



**Note** The AP image pre-download feature is not supported in bundle boot mode. For more information about the pre-download feature see the Cisco WLC 5700 Series *Preloading an Image to Access Points* chapter.

#### Related Topics

[Examples: Displaying Software Bootup in Install Mode](#), on page 2428

[Example: Emergency Installation](#), on page 2430

## Boot Mode for a Switch Stack

All the switches in a stack must be running in installed mode or bundle boot mode. A mixed mode stack is not supported. If a new switch tries to join the stack in a different boot mode than the active switch, the new switch is given a V-mismatch state.

If a mixed mode switch stack is booted at the same time, then only those switches that boot up in a different mode than the active go to the V-mismatch state. If the boot mode does not support auto-upgrade, then the switch stack members must be re-booted in the same boot mode as the active switch.

If the stack is running in installed mode, the auto-upgrade feature can be used to automatically upgrade the new switch that is attempting to join the switch stack.

The auto-upgrade feature changes the boot mode of the new switch to installed mode. If the stack is running in bundle boot mode, the auto-upgrade feature is not available. You will be required to use the bundle mode to boot the new switch so that it can join the switch stack.

This is an example of the state of a switch that attempts to join the switch stack when the boot mode is not compatible with the active switch:

```
Device# show switch

Switch/Stack Mac Address : 6400.f125.1100 - Local Mac Address
Mac persistency wait time: Indefinite
H/W Current
Switch#   Role   Mac Address      Priority Version   State
-----
1         Member 6400 f125.1a00   1         0         V-Mismatch
*2        Active 6400.f125.1100  1         V01        Ready
Device
```

## Devices Information Assignment

You can assign IP information through the device setup program, through a DHCP server, or manually.

Use the device setup program if you want to be prompted for specific IP information. With this program, you can also configure a hostname and an enable secret password.

It gives you the option of assigning a Telnet password (to provide security during remote management) and configuring your switch as a command or member switch of a cluster or as a standalone switch.

Use a DHCP server for centralized control and automatic assignment of IP information after the server is configured.



**Note** If you are using DHCP, do not respond to any of the questions in the setup program until the device receives the dynamically assigned IP address and reads the configuration file.

If you are an experienced user familiar with the device configuration steps, manually configure the device. Otherwise, use the setup program described in the *Boot Process* section.

## Default Switch Information

*Table 188: Default Switch Information*

| Feature                              | Default Setting                                  |
|--------------------------------------|--------------------------------------------------|
| IP address and subnet mask           | No IP address or subnet mask are defined.        |
| Default gateway                      | No default gateway is defined.                   |
| Enable secret password               | No password is defined.                          |
| Hostname                             | The factory-assigned default hostname is Device. |
| Telnet password                      | No password is defined.                          |
| Cluster command switch functionality | Disabled.                                        |
| Cluster name                         | No cluster name is defined.                      |

## DHCP-Based Autoconfiguration Overview

DHCP provides configuration information to Internet hosts and internetworking devices. This protocol consists of two components: one for delivering configuration parameters from a DHCP server to a device and an operation for allocating network addresses to devices. DHCP is built on a client-server model, in which designated DHCP servers allocate network addresses and deliver configuration parameters to dynamically configured devices. The device can act as both a DHCP client and a DHCP server.

During DHCP-based autoconfiguration, your device (DHCP client) is automatically configured at startup with IP address information and a configuration file.

With DHCP-based autoconfiguration, no DHCP client-side configuration is needed on your device. However, you need to configure the DHCP server for various lease options associated with IP addresses.

If you want to use DHCP to relay the configuration file location on the network, you might also need to configure a Trivial File Transfer Protocol (TFTP) server and a Domain Name System (DNS) server.



**Note** We recommend a redundant connection between a switch stack and the DHCP, DNS, and TFTP servers. This is to help ensure that these servers remain accessible in case one of the connected stack members is removed from the switch stack.

The DHCP server for your device can be on the same LAN or on a different LAN than the device. If the DHCP server is running on a different LAN, you should configure a DHCP relay device between your device and the DHCP server. A relay device forwards broadcast traffic between two directly connected LANs. A router does not forward broadcast packets, but it forwards packets based on the destination IP address in the received packet.

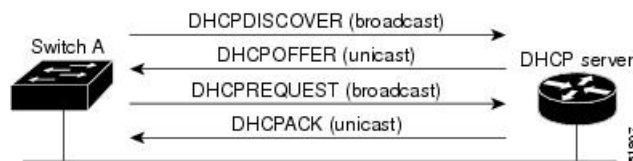
DHCP-based autoconfiguration replaces the BOOTP client functionality on your device.

## DHCP Client Request Process

When you boot up your device, the DHCP client is invoked and requests configuration information from a DHCP server when the configuration file is not present on the device. If the configuration file is present and the configuration includes the **ip address dhcp** interface configuration command on specific routed interfaces, the DHCP client is invoked and requests the IP address information for those interfaces.

This is the sequence of messages that are exchanged between the DHCP client and the DHCP server.

**Figure 144: DHCP Client and Server Message Exchange**



The client, Device A, broadcasts a DHCPDISCOVER message to locate a DHCP server. The DHCP server offers configuration parameters (such as an IP address, subnet mask, gateway IP address, DNS IP address, a lease for the IP address, and so forth) to the client in a DHCPOFFER unicast message.

In a DHCPREQUEST broadcast message, the client returns a formal request for the offered configuration information to the DHCP server. The formal request is broadcast so that all other DHCP servers that received the DHCPDISCOVER broadcast message from the client can reclaim the IP addresses that they offered to the client.

The DHCP server confirms that the IP address has been allocated to the client by returning a DHCPACK unicast message to the client. With this message, the client and server are bound, and the client uses configuration information received from the server. The amount of information the device receives depends on how you configure the DHCP server.

If the configuration parameters sent to the client in the DHCPOFFER unicast message are invalid (a configuration error exists), the client returns a DHCPDECLINE broadcast message to the DHCP server.

The DHCP server sends the client a DHCPNAK denial broadcast message, which means that the offered configuration parameters have not been assigned, that an error has occurred during the negotiation of the parameters, or that the client has been slow in responding to the DHCPOFFER message (the DHCP server assigned the parameters to another client).

A DHCP client might receive offers from multiple DHCP or BOOTP servers and can accept any of the offers; however, the client usually accepts the first offer it receives. The offer from the DHCP server is not a guarantee that the IP address is allocated to the client; however, the server usually reserves the address until the client has had a chance to formally request the address. If the device accepts replies from a BOOTP server and configures itself, the device broadcasts, instead of unicasts, TFTP requests to obtain the device configuration file.

The DHCP hostname option allows a group of devices to obtain hostnames and a standard configuration from the central management DHCP server. A client (device) includes in its DHCPDISCOVER message an option

12 field used to request a hostname and other configuration parameters from the DHCP server. The configuration files on all clients are identical except for their DHCP-obtained hostnames.

If a client has a default hostname (the **hostname name** global configuration command is not configured or the **no hostname** global configuration command is entered to remove the hostname), the DHCP hostname option is not included in the packet when you enter the **ip address dhcp** interface configuration command. In this case, if the client receives the DHCP hostname option from the DHCP interaction while acquiring an IP address for an interface, the client accepts the DHCP hostname option and sets the flag to show that the system now has a hostname configured.

## DHCP-based Autoconfiguration and Image Update

You can use the DHCP image upgrade features to configure a DHCP server to download both a new image and a new configuration file to one or more devices in a network. Simultaneous image and configuration upgrade for all switches in the network helps ensure that each new device added to a network receives the same image and configuration.

There are two types of DHCP image upgrades: DHCP autoconfiguration and DHCP auto-image update.

### Restrictions for DHCP-based Autoconfiguration

- The DHCP-based autoconfiguration with a saved configuration process stops if there is not at least one Layer 3 interface in an up state without an assigned IP address in the network.
- Unless you configure a timeout, the DHCP-based autoconfiguration with a saved configuration feature tries indefinitely to download an IP address.
- The auto-install process stops if a configuration file cannot be downloaded or if the configuration file is corrupted.
- The configuration file that is downloaded from TFTP is merged with the existing configuration in the running configuration but is not saved in the NVRAM unless you enter the **write memory** or **copy running-configuration startup-configuration** privileged EXEC command. If the downloaded configuration is saved to the startup configuration, the feature is not triggered during subsequent system restarts.

### DHCP Autoconfiguration

DHCP autoconfiguration downloads a configuration file to one or more devices in your network from a DHCP server. The downloaded configuration file becomes the running configuration of the device. It does not overwrite the bootup configuration saved in the flash, until you reload the device.

### DHCP Auto-Image Update

You can use DHCP auto-image upgrade with DHCP autoconfiguration to download both a configuration and a new image to one or more devices in your network. The device (or devices) downloading the new configuration and the new image can be blank (or only have a default factory configuration loaded).

If the new configuration is downloaded to a switch that already has a configuration, the downloaded configuration is appended to the configuration file stored on the switch. (Any existing configuration is not overwritten by the downloaded one.)

To enable a DHCP auto-image update on the device, the TFTP server where the image and configuration files are located must be configured with the correct option 67 (the configuration filename), option 66 (the DHCP

server hostname) option 150 (the TFTP server address), and option 125 (description of the Cisco IOS image file) settings.

After you install the device in your network, the auto-image update feature starts. The downloaded configuration file is saved in the running configuration of the device, and the new image is downloaded and installed on the device. When you reboot the device, the configuration is stored in the saved configuration on the device.

## DHCP Server Configuration Guidelines

Follow these guidelines if you are configuring a device as a DHCP server:

- You should configure the DHCP server with reserved leases that are bound to each device by the device hardware address.
- If you want the device to receive IP address information, you must configure the DHCP server with these lease options:
  - IP address of the client (required)
  - Subnet mask of the client (required)
  - DNS server IP address (optional)
  - Router IP address (default gateway address to be used by the device) (required)
- If you want the device to receive the configuration file from a TFTP server, you must configure the DHCP server with these lease options:
  - TFTP server name (required)
  - Boot filename (the name of the configuration file that the client needs) (recommended)
  - Hostname (optional)
- Depending on the settings of the DHCP server, the device can receive IP address information, the configuration file, or both.
- If you do not configure the DHCP server with the lease options described previously, it replies to client requests with only those parameters that are configured. If the IP address and the subnet mask are not in the reply, the device is not configured. If the router IP address or the TFTP server name are not found, the device might send broadcast, instead of unicast, TFTP requests. Unavailability of other lease options does not affect autoconfiguration.
- The device can act as a DHCP server. By default, the Cisco IOS DHCP server and relay agent features are enabled on your device but are not configured. (These features are not operational.)

## Purpose of the TFTP Server

Based on the DHCP server configuration, the device attempts to download one or more configuration files from the TFTP server. If you configured the DHCP server to respond to the device with all the options required for IP connectivity to the TFTP server, and if you configured the DHCP server with a TFTP server name, address, and configuration filename, the device attempts to download the specified configuration file from the specified TFTP server.

If you did not specify the configuration filename, the TFTP server, or if the configuration file could not be downloaded, the device attempts to download a configuration file by using various combinations of filenames

and TFTP server addresses. The files include the specified configuration filename (if any) and these files: `network-config`, `cisconet.cfg`, `hostname.config`, or `hostname.cfg`, where *hostname* is the device's current hostname. The TFTP server addresses used include the specified TFTP server address (if any) and the broadcast address (255.255.255.255).

For the device to successfully download a configuration file, the TFTP server must contain one or more configuration files in its base directory. The files can include these files:

- The configuration file named in the DHCP reply (the actual device configuration file).
- The `network-config` or the `cisconet.cfg` file (known as the default configuration files).
- The `router-config` or the `ciscotr.cfg` file (These files contain commands common to all devices. Normally, if the DHCP and TFTP servers are properly configured, these files are not accessed.)

If you specify the TFTP server name in the DHCP server-lease database, you must also configure the TFTP server name-to-IP-address mapping in the DNS-server database.

If the TFTP server to be used is on a different LAN from the device, or if it is to be accessed by the device through the broadcast address (which occurs if the DHCP server response does not contain all the required information described previously), a relay must be configured to forward the TFTP packets to the TFTP server. The preferred solution is to configure the DHCP server with all the required information.

## Purpose of the DNS Server

The DHCP server uses the DNS server to resolve the TFTP server name to an IP address. You must configure the TFTP server name-to-IP address map on the DNS server. The TFTP server contains the configuration files for the device.

You can configure the IP addresses of the DNS servers in the lease database of the DHCP server from where the DHCP replies will retrieve them. You can enter up to two DNS server IP addresses in the lease database.

The DNS server can be on the same LAN or on a different LAN from the device. If it is on a different LAN, the device must be able to access it through a router.

## How to Obtain Configuration Files

Depending on the availability of the IP address and the configuration filename in the DHCP reserved lease, the device obtains its configuration information in these ways:

- The IP address and the configuration filename is reserved for the device and provided in the DHCP reply (one-file read method).

The device receives its IP address, subnet mask, TFTP server address, and the configuration filename from the DHCP server. The device sends a unicast message to the TFTP server to retrieve the named configuration file from the base directory of the server and upon receipt, it completes its boot up process.

- The IP address and the configuration filename is reserved for the device, but the TFTP server address is not provided in the DHCP reply (one-file read method).

The device receives its IP address, subnet mask, and the configuration filename from the DHCP server. The device sends a broadcast message to a TFTP server to retrieve the named configuration file from the base directory of the server, and upon receipt, it completes its boot-up process.

- Only the IP address is reserved for the device and provided in the DHCP reply. The configuration filename is not provided (two-file read method).

The device receives its IP address, subnet mask, and the TFTP server address from the DHCP server. The device sends a unicast message to the TFTP server to retrieve the network-config or ciscoet.cfg default configuration file. (If the network-config file cannot be read, the device reads the ciscoet.cfg file.)

The default configuration file contains the hostnames-to-IP-address mapping for the device. The device fills its host table with the information in the file and obtains its hostname. If the hostname is not found in the file, the device uses the hostname in the DHCP reply. If the hostname is not specified in the DHCP reply, the device uses the default *Switch* as its hostname.

After obtaining its hostname from the default configuration file or the DHCP reply, the device reads the configuration file that has the same name as its hostname (*hostname-config* or *hostname.cfg*, depending on whether network-config or ciscoet.cfg was read earlier) from the TFTP server. If the ciscoet.cfg file is read, the filename of the host is truncated to eight characters.

If the device cannot read the network-config, ciscoet.cfg, or the hostname file, it reads the router-config file. If the device cannot read the router-config file, it reads the ciscortr.cfg file.



---

**Note** The device broadcasts TFTP server requests if the TFTP server is not obtained from the DHCP replies, if all attempts to read the configuration file through unicast transmissions fail, or if the TFTP server name cannot be resolved to an IP address.

---

## How to Control Environment Variables

With a normally operating device, you enter the boot loader mode only through the console connection configured for 9600 bps. Unplug the device power cord, and press the **Mode** button while reconnecting the power cord. You can release the **Mode** button after all the amber system LEDs turn on and remain solid. The boot loader device prompt then appears.

The device boot loader software provides support for nonvolatile environment variables, which can be used to control how the boot loader, or any other software running on the system, operates. Boot loader environment variables are similar to environment variables that can be set on UNIX or DOS systems.

Environment variables that have values are stored in flash memory outside of the flash file system.

Each line in these files contains an environment variable name and an equal sign followed by the value of the variable. A variable has no value if it is not present; it has a value if it is listed even if the value is a null string. A variable that is set to a null string (for example, “”) is a variable with a value. Many environment variables are predefined and have default values.

You can change the settings of the environment variables by accessing the boot loader or by using Cisco IOS commands. Under normal circumstances, it is not necessary to alter the setting of the environment variables.



## Common Environment Variables

This table describes the function of the most common environment variables.

**Table 189: Common Environment Variables**

| Variable    | Boot Loader Command                                                                                                                                                                                                                                                                                                                          | Cisco IOS Global Configuration Command                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BOOT        | <p><b>set BOOT</b> <i>filesystem :/file-url</i> ...</p> <p>A semicolon-separated list of executable files to try to load and execute when automatically booting.</p>                                                                                                                                                                         | <p><b>boot system</b> <i>{filesystem : /file-url ...   switch {number   all}}</i></p> <p>Specifies the Cisco IOS image to load during the next boot cycle and the stack members on which the image is loaded. This command changes the setting of the BOOT environment variable.</p> <p>The package provisioning file, also referred to as the <i>packages.conf</i> file, is used by the system to determine which software packages to activate during boot up.</p> <ul style="list-style-type: none"> <li>When booting in installed mode, the package provisioning file specified in the <b>boot</b> command is used to determine which packages to activate. For example <b>boot flash:packages.conf</b>.</li> <li>When booting in bundle mode, the package provisioning file contained in the booted bundle is used to activate the packages included in the bundle. For example, <b>boot flash:image.bin</b>.</li> </ul> |
| MANUAL_BOOT | <p><b>set MANUAL_BOOT</b> <b>yes</b></p> <p>Decides whether the switch automatically or manually boots.</p> <p>Valid values are 1, yes, 0, and no. If it is set to no or 0, the boot loader attempts to automatically boot up the system. If it is set to anything else, you must manually boot up the switch from the boot loader mode.</p> | <p><b>boot manual</b></p> <p>Enables manually booting the switch during the next boot cycle and changes the setting of the MANUAL_BOOT environment variable.</p> <p>The next time you reboot the system, the switch is in boot loader mode. To boot up the system, use the <b>boot flash:</b> <i>filesystem :/file-url</i> boot loader command, and specify the name of the bootable image.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

| Variable        | Boot Loader Command                                                                                                                                         | Cisco IOS Global Configuration Command                                                                                                                                                                                    |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CONFIG_FILE     | <b>set CONFIG_FILE flash:/<i>file-url</i></b><br>Changes the filename that Cisco IOS uses to read and write a nonvolatile copy of the system configuration. | <b>boot config-file flash:/<i>file-url</i></b><br>Specifies the filename that Cisco IOS uses to read and write a nonvolatile copy of the system configuration. This command changes the CONFIG_FILE environment variable. |
| SWITCH_NUMBER   | <b>set SWITCH_NUMBER <i>stack-member-number</i></b><br>Changes the member number of a stack member.                                                         | <b>switch <i>current-stack-member-number</i> renumber <i>new-stack-member-number</i></b><br>Changes the member number of a stack member.                                                                                  |
| SWITCH_PRIORITY | <b>set SWITCH_PRIORITY <i>stack-member-number</i></b><br>Changes the priority value of a stack member.                                                      | <b>switch <i>stack-member-number</i> priority <i>priority-number</i></b><br>Changes the priority value of a stack member.                                                                                                 |
| BAUD            | <b>set BAUD <i>baud-rate</i></b>                                                                                                                            | <b>line console 0<br/>speed <i>speed-value</i></b><br>Configures the baud rate.                                                                                                                                           |
| ENABLE_BREAK    | <b>set ENABLE_BREAK yes/no</b>                                                                                                                              | <b>boot enable-break switch yes/no</b><br>Enables a break to the auto-boot cycle. You have 5 seconds to enter the <b>break</b> command.                                                                                   |

## Environment Variables for TFTP

When the switch is connected to a PC through the Ethernet management port, you can download or upload a configuration file to the boot loader by using TFTP. Make sure the environment variables in this table are configured.

**Table 190: Environment Variables for TFTP**

| Variable   | Description                                                                                                                                                                                                                                                                                                                        |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MAC_ADDR   | Specifies the MAC address of the switch.<br><br><b>Note</b> We recommend that you do not modify this variable.<br><br>However, if you modify this variable after the boot loader is up or the value is different from the saved value, enter this command before using TFTP. A reset is required for the new value to take effect. |
| IP_ADDRESS | Specifies the IP address and the subnet mask for the associated IP subnet of the switch.                                                                                                                                                                                                                                           |

| Variable       | Description                                                      |
|----------------|------------------------------------------------------------------|
| DEFAULT_ROUTER | Specifies the IP address and subnet mask of the default gateway. |

## Scheduled Reload of the Software Image

You can schedule a reload of the software image to occur on the device at a later time (for example, late at night or during the weekend when the device is used less), or you can synchronize a reload network-wide (for example, to perform a software upgrade on all devices in the network).



**Note** A scheduled reload must take place within approximately 24 days.

You have these reload options:

- Reload of the software to take effect in the specified minutes or hours and minutes. The reload must take place within approximately 24 hours. You can specify the reason for the reload in a string up to 255 characters in length.
- Reload of the software to take place at the specified time (using a 24-hour clock). If you specify the month and day, the reload is scheduled to take place at the specified time and date. If you do not specify the month and day, the reload takes place at the specified time on the current day (if the specified time is later than the current time) or on the next day (if the specified time is earlier than the current time). Specifying 00:00 schedules the reload for midnight.

The **reload** command halts the system. If the system is not set to manually boot up, it reboots itself.

If your device is configured for manual booting, do not reload it from a virtual terminal. This restriction prevents the device from entering the boot loader mode and then taking it from the remote user's control.

If you modify your configuration file, the device prompts you to save the configuration before reloading. During the save operation, the system requests whether you want to proceed with the save if the CONFIG\_FILE environment variable points to a startup configuration file that no longer exists. If you proceed in this situation, the system enters setup mode upon reload.

To cancel a previously scheduled reload, use the **reload cancel** privileged EXEC command.

## How to Perform Device Setup Configuration

Using DHCP to download a new image and a new configuration to a device requires that you configure at least two devices. One device acts as a DHCP and TFTP server and the second device (client) is configured to download either a new configuration file or a new configuration file and a new image file.

### Configuring DHCP Autoconfiguration (Only Configuration File)

This task describes how to configure DHCP autoconfiguration of the TFTP and DHCP settings on an existing device in the network so that it can support the autoconfiguration of a new device.

## Procedure

|               | Command or Action                                                                                                                               | Purpose                                                                                                                                                                                                                                                                                                              |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br><br>Device# <b>configure terminal</b>                                                           | Enters global configuration mode.                                                                                                                                                                                                                                                                                    |
| <b>Step 2</b> | <b>ip dhcp pool <i>poolname</i></b><br><b>Example:</b><br><br>Device (config)# <b>ip dhcp pool pool</b>                                         | Creates a name for the DHCP server address pool, and enters DHCP pool configuration mode.                                                                                                                                                                                                                            |
| <b>Step 3</b> | <b>boot <i>filename</i></b><br><b>Example:</b><br><br>Device (dhcp-config)# <b>boot config-boot.text</b>                                        | Specifies the name of the configuration file that is used as a boot image.                                                                                                                                                                                                                                           |
| <b>Step 4</b> | <b>network <i>network-number mask prefix-length</i></b><br><b>Example:</b><br><br>Device (dhcp-config)# <b>network 10.10.10.0 255.255.255.0</b> | Specifies the subnet network number and mask of the DHCP address pool.<br><br><b>Note</b> The prefix length specifies the number of bits that comprise the address prefix. The prefix is an alternative way of specifying the network mask of the client. The prefix length must be preceded by a forward slash (/). |
| <b>Step 5</b> | <b>default-router <i>address</i></b><br><b>Example:</b><br><br>Device (dhcp-config)# <b>default-router 10.10.10.1</b>                           | Specifies the IP address of the default router for a DHCP client.                                                                                                                                                                                                                                                    |
| <b>Step 6</b> | <b>option 150 <i>address</i></b><br><b>Example:</b><br><br>Device (dhcp-config)# <b>option 150 10.10.10.1</b>                                   | Specifies the IP address of the TFTP server.                                                                                                                                                                                                                                                                         |
| <b>Step 7</b> | <b>exit</b><br><b>Example:</b>                                                                                                                  | Returns to global configuration mode.                                                                                                                                                                                                                                                                                |

|                | Command or Action                                                                                                            | Purpose                                                                       |
|----------------|------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
|                | Device (dhcp-config) # <b>exit</b>                                                                                           |                                                                               |
| <b>Step 8</b>  | <b>tftp-server flash:filename.text</b><br><b>Example:</b><br><br>Device (config) # <b>tftp-server flash:config-boot.text</b> | Specifies the configuration file on the TFTP server.                          |
| <b>Step 9</b>  | <b>interface interface-id</b><br><b>Example:</b><br><br>Device (config) # <b>interface gigabitethernet 1/0/4</b>             | Specifies the address of the client that will receive the configuration file. |
| <b>Step 10</b> | <b>no switchport</b><br><b>Example:</b><br><br>Device (config-if) # <b>no switchport</b>                                     | Puts the interface into Layer 3 mode.                                         |
| <b>Step 11</b> | <b>ip address address mask</b><br><b>Example:</b><br><br>Device (config-if) # <b>ip address 10.10.10.1 255.255.255.0</b>     | Specifies the IP address and mask for the interface.                          |
| <b>Step 12</b> | <b>end</b><br><b>Example:</b><br><br>Device (config-if) # <b>end</b>                                                         | Returns to privileged EXEC mode.                                              |

**Related Topics**

[Example: Configuring a Device as a DHCP Server](#), on page 2432

## Configuring DHCP Auto-Image Update (Configuration File and Image)

This task describes DHCP autoconfiguration to configure TFTP and DHCP settings on an existing device to support the installation of a new switch.

**Before you begin**

You must first create a text file (for example, `autoinstall_dhcp`) that will be uploaded to the device. In the text file, put the name of the image that you want to download (for example,

c3750e-ipservices-mz.122-44.3.SE.tarc3750x-ipservices-mz.122-53.3.SE2.tar). This image must be a tar and not a bin file.

### Procedure

|               | Command or Action                                                                                                                           | Purpose                                                                                                                                                                                                                                                                                                              |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                           | Enters global configuration mode.                                                                                                                                                                                                                                                                                    |
| <b>Step 2</b> | <b>ip dhcp pool <i>poolname</i></b><br><b>Example:</b><br>Device (config)# <b>ip dhcp pool pool1</b>                                        | Creates a name for the DHCP server address pool and enter DHCP pool configuration mode.                                                                                                                                                                                                                              |
| <b>Step 3</b> | <b>boot <i>filename</i></b><br><b>Example:</b><br>Device (dhcp-config)# <b>boot config-boot.text</b>                                        | Specifies the name of the file that is used as a boot image.                                                                                                                                                                                                                                                         |
| <b>Step 4</b> | <b>network <i>network-number mask prefix-length</i></b><br><b>Example:</b><br>Device (dhcp-config)# <b>network 10.10.10.0 255.255.255.0</b> | Specifies the subnet network number and mask of the DHCP address pool.<br><br><b>Note</b> The prefix length specifies the number of bits that comprise the address prefix. The prefix is an alternative way of specifying the network mask of the client. The prefix length must be preceded by a forward slash (/). |
| <b>Step 5</b> | <b>default-router <i>address</i></b><br><b>Example:</b><br>Device (dhcp-config)# <b>default-router 10.10.10.1</b>                           | Specifies the IP address of the default router for a DHCP client.                                                                                                                                                                                                                                                    |
| <b>Step 6</b> | <b>option 150 <i>address</i></b><br><b>Example:</b><br>Device (dhcp-config)# <b>option 150 10.10.10.1</b>                                   | Specifies the IP address of the TFTP server.                                                                                                                                                                                                                                                                         |

|                | Command or Action                                                                                                                                    | Purpose                                                                        |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| <b>Step 7</b>  | <b>option 125 hex</b><br><b>Example:</b><br><pre>Device(dhcp-config)# option 125 hex 0000.0009.0a05.08661.7574.6f69.6e73.7461.6c6c.5f64.686370</pre> | Specifies the path to the text file that describes the path to the image file. |
| <b>Step 8</b>  | <b>copy tftp flash filename.txt</b><br><b>Example:</b><br><pre>Device(config)# copy tftp flash image.bin</pre>                                       | Uploads the text file to the device.                                           |
| <b>Step 9</b>  | <b>copy tftp flash imagename.bin</b><br><b>Example:</b><br><pre>Device(config)# copy tftp flash image.bin</pre>                                      | Uploads the tar file for the new image to the device.                          |
| <b>Step 10</b> | <b>exit</b><br><b>Example:</b><br><pre>Device(dhcp-config)# exit</pre>                                                                               | Returns to global configuration mode.                                          |
| <b>Step 11</b> | <b>tftp-server flash: config.text</b><br><b>Example:</b><br><pre>Device(config)# tftp-server flash:config-boot.text</pre>                            | Specifies the Cisco IOS configuration file on the TFTP server.                 |
| <b>Step 12</b> | <b>tftp-server flash: imagename.bin</b><br><b>Example:</b><br><pre>Device(config)# tftp-server flash:image.bin</pre>                                 | Specifies the image name on the TFTP server.                                   |
| <b>Step 13</b> | <b>tftp-server flash: filename.txt</b><br><b>Example:</b><br><pre>Device(config)# tftp-server flash:boot-config.text</pre>                           | Specifies the text file that contains the name of the image file to download   |

|                | Command or Action                                                                                                             | Purpose                                                                       |
|----------------|-------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| <b>Step 14</b> | <b>interface</b> <i>interface-id</i><br><b>Example:</b><br><pre>Device(config)# interface gigabitethernet 1/0/4</pre>         | Specifies the address of the client that will receive the configuration file. |
| <b>Step 15</b> | <b>no switchport</b><br><b>Example:</b><br><pre>Device(config-if)# no switchport</pre>                                        | Puts the interface into Layer 3 mode.                                         |
| <b>Step 16</b> | <b>ip address</b> <i>address mask</i><br><b>Example:</b><br><pre>Device(config-if)# ip address 10.10.10.1 255.255.255.0</pre> | Specifies the IP address and mask for the interface.                          |
| <b>Step 17</b> | <b>end</b><br><b>Example:</b><br><pre>Device(config-if)# end</pre>                                                            | Returns to privileged EXEC mode.                                              |
| <b>Step 18</b> | <b>copy running-config startup-config</b><br><b>Example:</b><br><pre>Device(config-if)# end</pre>                             | (Optional) Saves your entries in the configuration file.                      |

**Related Topics**

[Example: Configuring DHCP Auto-Image Update](#), on page 2432

## Configuring the Client to Download Files from DHCP Server



**Note** You should only configure and enable the Layer 3 interface. Do not assign an IP address or DHCP-based autoconfiguration with a saved configuration.



**Procedure**

|               | <b>Command or Action</b>                                                                                                                                                                                                                                     | <b>Purpose</b>                                                                                                                                                                                                       |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <code>configure terminal</code>                                                                                                                                                                      | Enters global configuration mode.                                                                                                                                                                                    |
| <b>Step 2</b> | <b>boot host dhcp</b><br><b>Example:</b><br>Device(conf)# <code>boot host dhcp</code>                                                                                                                                                                        | Enables autoconfiguration with a saved configuration.                                                                                                                                                                |
| <b>Step 3</b> | <b>boot host retry timeout <i>timeout-value</i></b><br><b>Example:</b><br>Device(conf)# <code>boot host retry timeout 300</code>                                                                                                                             | (Optional) Sets the amount of time the system tries to download a configuration file.<br><br><b>Note</b> If you do not set a timeout, the system will try indefinitely to obtain an IP address from the DHCP server. |
| <b>Step 4</b> | <b>banner config-save ^C <i>warning-message</i> ^C</b><br><b>Example:</b><br>Device(conf)# <code>banner config-save ^C Caution - Saving Configuration File to NVRAM May Cause You to No longer Automatically Download Configuration Files at Reboot^C</code> | (Optional) Creates warning messages to be displayed when you try to save the configuration file to NVRAM.                                                                                                            |
| <b>Step 5</b> | <b>end</b><br><b>Example:</b><br>Device(config-if)# <code>end</code>                                                                                                                                                                                         | Returns to privileged EXEC mode.                                                                                                                                                                                     |
| <b>Step 6</b> | <b>show boot</b><br><b>Example:</b><br>Device# <code>show boot</code>                                                                                                                                                                                        | Verifies the configuration.                                                                                                                                                                                          |

**Related Topics**

[Example: Configuring a Device to Download Configurations from a DHCP Server](#), on page 2432

## Manually Assigning IP Information to Multiple SVIs

This task describes how to manually assign IP information to multiple switched virtual interfaces (SVIs):

## Procedure

|               | Command or Action                                                                                                                     | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                     | Enters global configuration mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Step 2</b> | <b>interface vlan <i>vlan-id</i></b><br><b>Example:</b><br>Device(config)# <b>interface vlan 99</b>                                   | Enters interface configuration mode, and enters the VLAN to which the IP information is assigned. The range is 1 to 4094.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Step 3</b> | <b>ip address <i>ip-address subnet-mask</i></b><br><b>Example:</b><br>Device(config-vlan)# <b>ip address 10.10.10.2 255.255.255.0</b> | Enters the IP address and subnet mask.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Step 4</b> | <b>exit</b><br><b>Example:</b><br>Device(config-vlan)# <b>exit</b>                                                                    | Returns to global configuration mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Step 5</b> | <b>ip default-gateway <i>ip-address</i></b><br><b>Example:</b><br>Device(config)# <b>ip default-gateway 10.10.10.1</b>                | <p>Enters the IP address of the next-hop router interface that is directly connected to the device where a default gateway is being configured. The default gateway receives IP packets with unresolved destination IP addresses from the device.</p> <p>Once the default gateway is configured, the device has connectivity to the remote networks with which a host needs to communicate.</p> <p><b>Note</b> When your device is configured to route with IP, it does not need to have a default gateway set.</p> <p><b>Note</b> The device capwap relays on default-gateway configuration to support routed access point join the device.</p> |
| <b>Step 6</b> | <b>end</b><br><b>Example:</b>                                                                                                         | Returns to privileged EXEC mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

|               | Command or Action                                                                                       | Purpose                                  |
|---------------|---------------------------------------------------------------------------------------------------------|------------------------------------------|
|               | Device(config)# <b>end</b>                                                                              |                                          |
| <b>Step 7</b> | <b>show interfaces vlan <i>vlan-id</i></b><br><b>Example:</b><br>Device# <b>show interfaces vlan 99</b> | Verifies the configured IP address.      |
| <b>Step 8</b> | <b>show ip redirects</b><br><b>Example:</b><br>Device# <b>show ip redirects</b>                         | Verifies the configured default gateway. |

## Modifying the Device Startup Configuration

### Specifying the Filename to Read and Write the System Configuration

By default, the Cisco IOS software uses the config.text file to read and write a nonvolatile copy of the system configuration. However, you can specify a different filename, which will be loaded during the next boot cycle.

#### Before you begin

Use a standalone device for this task.

#### Procedure

|               | Command or Action                                                                                     | Purpose                                                                                                                                                                                                    |
|---------------|-------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Switch# <b>configure terminal</b>                     | Enters global configuration mode.                                                                                                                                                                          |
| <b>Step 2</b> | <b>boot flash:<i>file-url</i></b><br><b>Example:</b><br>Switch(config)# <b>boot flash:config.text</b> | Specifies the configuration file to load during the next boot cycle.<br><br><i>file-url</i> —The path (directory) and the configuration filename.<br><br>Filenames and directory names are case-sensitive. |
| <b>Step 3</b> | <b>end</b><br><b>Example:</b>                                                                         | Returns to privileged EXEC mode.                                                                                                                                                                           |

|               | Command or Action                                                                                                 | Purpose                                                                                                                             |
|---------------|-------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
|               | Switch(config)# <b>end</b>                                                                                        |                                                                                                                                     |
| <b>Step 4</b> | <b>show boot</b><br><b>Example:</b><br>Switch# <b>show boot</b>                                                   | Verifies your entries.<br>The <b>boot</b> global configuration command changes the setting of the CONFIG_FILE environment variable. |
| <b>Step 5</b> | <b>copy running-config startup-config</b><br><b>Example:</b><br>Switch# <b>copy running-config startup-config</b> | (Optional) Saves your entries in the configuration file.                                                                            |

## Manually Booting the Switch

By default, the switch automatically boots up; however, you can configure it to manually boot up.

### Before you begin

Use a standalone switch for this task.

### Procedure

|               | Command or Action                                                                 | Purpose                                                                                                                      |
|---------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b> | Enters global configuration mode.                                                                                            |
| <b>Step 2</b> | <b>boot manual</b><br><b>Example:</b><br>Device(config)# <b>boot manual</b>       | Enables the switch to manually boot up during the next boot cycle.                                                           |
| <b>Step 3</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b>                       | Returns to privileged EXEC mode.                                                                                             |
| <b>Step 4</b> | <b>show boot</b><br><b>Example:</b>                                               | Verifies your entries.<br>The <b>boot manual</b> global command changes the setting of the MANUAL_BOOT environment variable. |

|               | Command or Action                                                                                                             | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------|-------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | Device# <code>show boot</code>                                                                                                | <p>The next time you reboot the system, the switch is in boot loader mode, shown by the <code>switch:</code> prompt. To boot up the system, use the <code>boot filesystem:/file-url</code> boot loader command.</p> <ul style="list-style-type: none"> <li><code>filesystem:</code>—Uses flash: for the system board flash device.<br/>Switch: <code>boot flash:</code></li> <li>For <code>file-url</code>—Specifies the path (directory) and the name of the bootable image.</li> </ul> <p>Filenames and directory names are case-sensitive.</p> |
| <b>Step 5</b> | <p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre> | (Optional) Saves your entries in the configuration file.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

## Booting the Device in Installed Mode

### Procedure

|               | Command or Action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Purpose                                                                                                                                                                                                   |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <p><b>cp source_file_path destination_file_path</b></p> <p><b>Example:</b></p> <pre>Switch# copy ftp://10.0.0.6/cat3k_caa-universal9.SSA.03.12.02.PP.15-12.02.PP.15-12.02.PP.bin flash:</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                          | (Optional) Copies the bin file ( <code>image.bin</code> ) from the FTP or TFTP server to USB flash.                                                                                                       |
| <b>Step 2</b> | <p><b>request platform software package expand switch all file source_file_path to flash</b></p> <p><b>Example:</b></p> <p>Expanding the bin file from the TFTP server:</p> <pre>Switch# request platform software package expand switch all file ftp://10.0.0.2/cat3k_caa-universal9.SSA.03.09.37.EXP.150-9.37.EXP.bin to flash: Preparing expand operation ... [1]: Downloading file ftp://10.0.0.2/cat3k_caa-universal9.SSA.03.09.37.EXP.150-9.37.EXP.bin to active switch 1 [1]: Finished downloading file ftp://10.0.0.2/cat3k_caa-universal9.SSA.03.09.37.EXP.150-9.37.EXP.bin to active switch 1 [1]: Copying software from active switch</pre> | <p>Expands the bin file stored in flash, FTP, TFTP, HTTP, or HTTPS server on the booted device.</p> <p><b>Note</b> Ensure that the <code>packages.conf</code> file is available in the expanded list.</p> |

|               | Command or Action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Purpose                                                                                                                                                                                                                                          |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | <pre> 1 to switch 2 [1]: Finished copying software to switch 2 [1 2]: Expanding bundle cat3k_caa-universalk9.SSA.03.09.37.EXP.150-9.37.EXP.bin [1 2]: Copying package files [1 2]: Package files copied [1 2]: Finished expanding bundle cat3k_caa-universalk9.SSA.03.09.37.EXP.150-9.37.EXP.bin      18 -rw-    74387812   Dec 7 2012 05:55:43 +00:00 cat3k_caa-base.SSA.03.09.37.EXP.pkg     19 -rw-    2738868   Dec 7 2012 05:55:44 +00:00 cat3k_caa-drivers.SSA.03.09.37.EXP.pkg     20 -rw-    32465772   Dec 7 2012 05:55:44 +00:00 cat3k_caa-infra.SSA.03.09.37.EXP.pkg     21 -rw-    30389036   Dec 7 2012 05:55:44 +00:00 cat3k_caa-iosd-universalk9.SSA.150-9.37.EXP.pkg      22 -rw-    18342624   Dec 7 2012 05:55:44 +00:00 cat3k_caa-platform.SSA.03.09.37.EXP.pkg     23 -rw-    63374028   Dec 7 2012 05:55:44 +00:00 cat3k_caa-wcm.SSA.10.0.10.14.pkg     17 -rw-         1239   Dec 7 2012 05:56:29 +00:00 packages.conf </pre> |                                                                                                                                                                                                                                                  |
| <b>Step 3</b> | <p><b>reload</b></p> <p><b>Example:</b></p> <pre>Switch# reload</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <p>Reloads the device.</p> <p><b>Note</b> You can boot the device manually or automatically using the <code>packages.conf</code> file. If you are booting manually, you can proceed to Step 4. Otherwise, the device boots up automatically.</p> |
| <b>Step 4</b> | <p><b>boot flash:packages.conf</b></p> <p><b>Example:</b></p> <pre>Switch: boot flash:packages.conf</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <p>Boots the device with the <code>packages.conf</code> file.</p>                                                                                                                                                                                |
| <b>Step 5</b> | <p><b>show version</b></p> <p><b>Example:</b></p> <pre>switch# show version  Switch Ports Model          SW           Mode Version          SW Image ----- ----- ----     1 6          WS-C3850-6DS-S</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <p>Verifies that the device is in the <b>INSTALL</b> mode.</p>                                                                                                                                                                                   |

|  | Command or Action                          | Purpose |
|--|--------------------------------------------|---------|
|  | 03.09.26.EXP ct3850-ipervicesk9<br>INSTALL |         |

## Booting the Device in Bundle Mode

There are several methods by which you can boot the device—either by copying the bin file from the TFTP server and then boot the device, or by booting the device straight from flash or USB flash using the commands **boot flash:<image.bin>** or **boot usbflash0:<image.bin>**.

The following procedure explains how to boot the device from the TFTP server in the bundle mode.

### Procedure

|               | Command or Action                                                                                                                                                                                                     | Purpose                                                |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| <b>Step 1</b> | <b>switch:BOOT=&lt;source path of .bin file&gt;</b><br><br><b>Example:</b><br>switch BOOT tftp://10.0.0.2/cisco/ios/15.0.3/BS-150937/BS-150937.bin                                                                    | Sets the boot parameters.                              |
| <b>Step 2</b> | <b>boot</b><br><br><b>Example:</b><br>switch: boot                                                                                                                                                                    | Boots the device.                                      |
| <b>Step 3</b> | <b>show version</b><br><br><b>Example:</b><br>switch# show version<br><br>Switch Ports Model SW<br>Version SW Image Mode<br>-----<br>-----<br>----<br>1 6 WS-C3850-6DS-S<br>03.09.40.EXP ct3850-ipervicesk9<br>BUNDLE | Verifies that the device is in the <b>BUNDLE</b> mode. |

## Booting a Specific Software Image On a Switch Stack

By default, the switch attempts to automatically boot up the system using information in the BOOT environment variable. If this variable is not set, the switch attempts to load and execute the first executable image it can by performing a recursive, depth-first search throughout the flash file system. In a depth-first search of a directory, each encountered subdirectory is completely searched before continuing the search in the original directory. However, you can specify a specific image to boot up.

**Procedure**

|               | <b>Command or Action</b>                                                                                                                                                                     | <b>Purpose</b>                                                                                                                                                                                                                                                                                                             |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br><pre>Switch# configure terminal</pre>                                                                                                        | Enters global configuration mode.                                                                                                                                                                                                                                                                                          |
| <b>Step 2</b> | <b>boot system switch</b> { <i>number</i>   <b>all</b> }<br><b>Example:</b><br><pre>Switch(config)# boot system switch all flash:cat3850-universalk9.SSA.03.08.83.FMD.150-8.83.FMD.bin</pre> | (Optional) For switches in a stack, specifies the switch members on which the system image is loaded during the next boot cycle: <ul style="list-style-type: none"> <li>• Use <i>number</i> to specify a stack member. (Specify only one stack member.)</li> <li>• Use <b>all</b> to specify all stack members.</li> </ul> |
| <b>Step 3</b> | <b>end</b><br><b>Example:</b><br><pre>Switch(config)# end</pre>                                                                                                                              | Returns to privileged EXEC mode.                                                                                                                                                                                                                                                                                           |
| <b>Step 4</b> | <b>show boot system</b><br><b>Example:</b><br><pre>Switch# show boot system</pre>                                                                                                            | Verifies your entries.<br><br>The <b>boot system</b> global command changes the setting of the BOOT environment variable.<br><br>During the next boot cycle, the switch attempts to automatically boot up the system using information in the BOOT environment variable.                                                   |
| <b>Step 5</b> | <b>copy running-config startup-config</b><br><b>Example:</b><br><pre>Switch# copy running-config startup-config</pre>                                                                        | (Optional) Saves your entries in the configuration file.                                                                                                                                                                                                                                                                   |

**Configuring a Scheduled Software Image Reload**

This task describes how to configure your device to reload the software image at a later time.

**Procedure**

|               | <b>Command or Action</b>                     | <b>Purpose</b>                    |
|---------------|----------------------------------------------|-----------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b> | Enters global configuration mode. |



|               | Command or Action                                                                                                                                        | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | Device# <code>configure terminal</code>                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Step 2</b> | <b>copy running-config startup-config</b><br><b>Example:</b><br><code>copy running-config startup-config</code>                                          | Saves your device configuration information to the startup configuration before you use the <b>reload</b> command.                                                                                                                                                                                                                                                                                                               |
| <b>Step 3</b> | <b>reload in [hh:]mm [text]</b><br><b>Example:</b><br><pre>Device(config)# reload in 12  System configuration has been modified. Save? [yes/no]: y</pre> | Schedules a reload of the software to take affect in the specified minutes or hours and minutes. The reload must take place within approximately 24 days. You can specify the reason for the reload in a string up to 255 characters in length.                                                                                                                                                                                  |
| <b>Step 4</b> | <b>reload slot [stack-member-number]</b><br><b>Example:</b><br><pre>Device(config)# reload slot 6  Proceed with reload? [confirm] y</pre>                | Schedules a reload of the software in a switch stack.                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Step 5</b> | <b>reload at hh: mm [month day   day month] [text]</b><br><b>Example:</b><br><pre>Device(config)# reload at 14:00</pre>                                  | Specifies the time in hours and minutes for the reload to occur.<br><br><b>Note</b> Use the <b>at</b> keyword only if the device system clock has been set (through Network Time Protocol (NTP), the hardware calendar, or manually). The time is relative to the configured time zone on the device. To schedule reloads across several devices to occur simultaneously, the time on each device must be synchronized with NTP. |
| <b>Step 6</b> | <b>reload cancel</b><br><b>Example:</b><br><pre>Device(config)# reload cancel</pre>                                                                      | Cancels a previously scheduled reload.                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Step 7</b> | <b>show reload</b><br><b>Example:</b><br><pre>show reload</pre>                                                                                          | Displays information about a previously scheduled reload or identifies if a reload has been scheduled on the device.                                                                                                                                                                                                                                                                                                             |

# Monitoring Device Setup Configuration

## Example: Verifying the Device Running Configuration

```
Device# show running-config
Building configuration...

Current configuration: 1363 bytes
!
version 12.4
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname Stack1
!
enable secret 5 $1$ej9.$DMUvAUnZOAmvmgqBEzIxEO
!
.
<output truncated>
.
interface gigabitethernet6/0/2
mvr type source

<output truncated>

...!
interface VLAN1
 ip address 172.20.137.50 255.255.255.0
 no ip directed-broadcast
!
 ip default-gateway 172.20.137.1 !
!
snmp-server community private RW
snmp-server community public RO
snmp-server community private@es0 RW
snmp-server community public@es0 RO
snmp-server chassis-id 0x12
!
end
```

## Examples: Displaying Software Bootup in Install Mode

This example displays software bootup in install mode:

```
switch: boot flash:packages.conf

Getting rest of image
Reading full image into memory....done
Reading full base package into memory...: done = 74596432
Nova Bundle Image
-----
Kernel Address : 0x6042f354
Kernel Size : 0x318412/3245074
Initramfs Address : 0x60747768
```



```

Bootable image at @ ram:0x6042ff38
Bootable image segment 0 address range [0x81100000, 0x81b80000] is in range [0x80180000,
0x90000000].
#####
File "flash:cat3k_caa-universalk9.SSA.03.09.12.EMD.150-9.12.EMD.bin" uncompressed and
installed, entry point: 0x811060f0
Loading Linux kernel with entry point 0x811060f0 ...
Bootloader: Done loading app on core_mask: 0xf

### Launching Linux Kernel (flags = 0x5)

All packages are Digitally Signed
Starting System Services
Nov 7 09:45:49 %IOSXE-1-PLATFORM: process stack-mgr: %STACKMGR-1-DISC_START: Switch 2 is
starting stack discovery
#####
Nov 7 09:47:50 %IOSXE-1-PLATFORM: process stack-mgr: %STACKMGR-1-DISC_DONE: Switch 2 has
finished stack discovery
Nov 7 09:47:50 %IOSXE-1-PLATFORM: process stack-mgr: %STACKMGR-1-SWITCH_ADDED: Switch 2 has
been added to the stack
Nov 7 09:47:58 %IOSXE-1-PLATFORM: process stack-mgr: %STACKMGR-1-ACTIVE_ELECTED: Switch 2
has been elected ACTIVE

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Cisco IOS Software, IOS-XE Software, Catalyst L3 Switch Software (CAT3K_CAA-UNIVERSALK9-M),
Version 03.09.12.EMD
EARLY DEPLOYMENT ENGINEERING NOVA_WEEKLY BUILD, synced to DSGS_PI2_POSTPC_FLO_DSBU7_NG3K_1105
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Compiled Sun 04-Nov-12 22:53 by gereddy
License level to iosd is ipservices

```

### Related Topics

[Software Boot Modes](#), on page 2403

[Installed Boot Mode](#), on page 2403

[Bundle Boot Mode](#), on page 2403

## Example: Emergency Installation

This sample output is an example when the **emergency-install** boot command is initiated:

```

switch: emergency-install
tftp://192.0.2.47/cat3k/cat3k_caa-universalk9.SSA.03.09.12.EMD.150-9.12.EMD.bin

```

The bootflash will be erased during install operation, continue (y/n)?y



# Configuration Examples for Performing Device Setup

## Example: Configuring a Device as a DHCP Server

```
Device# configure terminal
Device(config)# ip dhcp pool pool1
Device(dhcp-config)# network 10.10.10.0 255.255.255.0
Device(dhcp-config)# boot config-boot.text
Device(dhcp-config)# default-router 10.10.10.1
Device(dhcp-config)# option 150 10.10.10.1
Device(dhcp-config)# exit
Device(config)# tftp-server flash:config-boot.text
Device(config)# interface gigabitethernet 1/0/4
Device(config-if)# no switchport
Device(config-if)# ip address 10.10.10.1 255.255.255.0
Device(config-if)# end
```

### Related Topics

[Configuring DHCP Autoconfiguration \(Only Configuration File\)](#), on page 2413

## Example: Configuring DHCP Auto-Image Update

```
Device# configure terminal
Device(config)# ip dhcp pool pool1
Device(dhcp-config)# network 10.10.10.0 255.255.255.0
Device(dhcp-config)# boot config-boot.text
Device(dhcp-config)# default-router 10.10.10.1
Device(dhcp-config)# option 150 10.10.10.1
Device(dhcp-config)# option 125 hex 0000.0009.0a05.08661.7574.6f69.6e73.7461.6c6c.5f64.686370

Device(dhcp-config)# exit
Device(config)# tftp-server flash:config-boot.text
Device(config)# tftp-server flash:image_name
Device(config)# tftp-server flash:boot-config.text
Device(config)# tftp-server flash:autoinstall_dhcp
Device(config)# interface gigabitethernet 1/0/4
Device(config-if)# no switchport
Device(config-if)# ip address 10.10.10.1 255.255.255.0
Device(config-if)# end
```

### Related Topics

[Configuring DHCP Auto-Image Update \(Configuration File and Image\)](#), on page 2415

## Example: Configuring a Device to Download Configurations from a DHCP Server

This example uses a Layer 3 SVI interface on VLAN 99 to enable DHCP-based autoconfiguration with a saved configuration:

```

Device# configure terminal
Device(config)# boot host dhcp
Device(config)# boot host retry timeout 300
Device(config)# banner config-save ^C Caution - Saving Configuration File to NVRAM May Cause
  You to No longer Automatically Download Configuration Files at Reboot^C
Device(config)# vlan 99
Device(config-vlan)# interface vlan 99
Device(config-if)# no shutdown
Device(config-if)# end
Device# show boot
BOOT path-list:
Config file:          flash:/config.text
Private Config file: flash:/private-config.text
Enable Break:        no
Manual Boot:         no
HELPER path-list:
NVRAM/Config file
  buffer size:       32768
Timeout for Config
  Download:          300 seconds
Config Download
  via DHCP:          enabled (next boot: enabled)
Device#

```

### Related Topics

[Configuring the Client to Download Files from DHCP Server](#), on page 2418

## Examples: Scheduling Software Image Reload

This example shows how to reload the software on the device on the current day at 7:30 p.m:

```

Device# reload at 19:30
Reload scheduled for 19:30:00 UTC Wed Jun 5 2013 (in 2 hours and 25 minutes)
Proceed with reload? [confirm]

```

This example shows how to reload the software on the device at a future time:

```

Device# reload at 02:00 jun 20
Reload scheduled for 02:00:00 UTC Thu Jun 20 2013 (in 344 hours and 53 minutes)
Proceed with reload? [confirm]

```

## Additional References For Performing Device Setup

### Related Documents

| Related Topic         | Document Title                                                      |
|-----------------------|---------------------------------------------------------------------|
| Device setup commands | <i>System Management Command Reference (Catalyst 3850 Switches)</i> |
| Boot loader commands  |                                                                     |

| Related Topic                                  | Document Title                                                                                          |
|------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| IOS XE DHCP configuration                      | <i>IP Addressing Configuration Guide Library, Cisco IOS XE Release 3S (Catalyst 3850 Switches)</i>      |
| Hardware installation                          | <i>Catalyst 3850 Switch Hardware Installation Guide</i>                                                 |
| Platform-independent command references        | <i>Configuration Fundamentals Command Reference, Cisco IOS XE Release 3S (Catalyst 3850 Switches)</i>   |
| Platform-independent configuration information | <i>Configuration Fundamentals Configuration Guide, Cisco IOS XE Release 3S (Catalyst 3850 Switches)</i> |

### Standards and RFCs

| Standard/RFC | Title |
|--------------|-------|
| None         | —     |

### MIBs

| MIB                                  | MIBs Link                                                                                                                                                                                                              |
|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| All supported MIBs for this release. | To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:<br><a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a> |

### Technical Assistance

| Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Link                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p> | <a href="http://www.cisco.com/support">http://www.cisco.com/support</a> |



# Installing WCM Sub-Package

This document explains the process to install wireless control module (WCM) sub-package in Cisco Catalyst 3850 and 3650 Series Switches.

The WCM sub-package, which consists of WCM module and AP images, upgrades features, supports new APs, and fixes known issues. It eliminates the need for a full image upgrade and the resulting network downtime by upgrading only the WCM portion of the image. For example, if the WCM fails to allow a new AP to join the network due to image version mis-match, you can upgrade only the WCM portion of the image to add support for the new AP. When the WCM is upgraded, all the APs in the network are automatically upgraded to the newer image.

## Benefits

- Fixes WCM bugs
- Supports new APs
- Updates features available in WCM

## Prerequisites

- The controller must be booted in install mode.
- WCM sub-package should be available in any of the sources supported by installer. For example, flash or TFTP or USB.

## Restrictions

- WCM sub-package can only be installed on previous minor versions of the 16.1 image (for example, WCM package from 16.01.YY(cat3k\_caa-wcm.16.01.YY.SSA.pkg) can be installed on 16.01.01 to 16.01.YY super package (cat3k\_caa-universalk9.16.01.[01-to-YY].SSA.bin).
- You should reboot the switch after an upgrade.

# Installing WCM Sub-Package

## Procedure

---

- Step 1** Upgrade controller WCM package.  
**request platform software package install switch all file flash: wcm\_sub\_package.pkg auto-copy**
- Step 2** (Optional) Download and install the AP image. This procedure reduces network downtime by pre-downloading and pre-programming APs with new image. Otherwise, when the controller reloads there will be a version mis-match between controller and APs and the APs will start to upgrade themselves using the new AP image, which may lead to longer downtime on the network.

**Note** After the download and install, wait for 30 seconds to ensure that the CLIs reach the AP.

- a) Push the new image to all connected APs.  
**ap image predownload**
- b) Monitor the progress of the download.  
**show ap image**
- c) Point the boot variable of all APs to the new image.  
**ap image swap**
- d) Reset the APs.  
**ap image reset**

**Step 3** Reload the controller. After the reload, the controller reloads with new WCM package and APs reloads with new AP image and they will start joining the upgraded controller.  
**reload**

---

## Feature History and Information For Performing Device Setup Configuration

| Command History | Release            | Modification                 |
|-----------------|--------------------|------------------------------|
|                 | Cisco IOS XE 3.2SE | This feature was introduced. |



## CHAPTER 130

# Configuring Autonomic Networking

- [Autonomic Networking, on page 2437](#)

## Autonomic Networking

Autonomic networking makes network devices intelligent by introducing self-management concepts that simplify network management for network operators.

## Prerequisites for Autonomic Networking

- The Autonomic Networking Infrastructure feature supports only Ethernet ports and IPv6 addresses.
- All interfaces are up by default to exchange adjacency discovery messages if there is no startup configuration in the corresponding device.
- The Autonomic Control Plane is automatically built between two adjacent devices supporting the autonomic networking infrastructure. The Ethernet interfaces on both devices need to be up, and the device should either be unconfigured (greenfield rollout) or have autonomic networking configured explicitly.
- The Autonomic Control Plane can also be automatically built between two adjacent devices if there is an intervening nonautonomic layer 2 cloud such as a Metro ethernet service. This is achieved by the Channel Discovery protocol on the autonomic devices. This protocol probes for working VLAN encapsulations.
- To build the ACP across intervening nonautonomic L3 devices, you should explicitly configure a tunnel between the autonomic devices and enable autonomic adjacency discovery on this tunnel.
- Autonomic Registrar, commonly known as *registrar*, is required for the Autonomic Networking Infrastructure feature to work. At least one device in the network must be configured as a registrar to enroll new devices into the autonomic domain.
- In a network where all the required devices are already enrolled into the autonomic domain, a registrar is not required.
- Each registrar supports only one autonomic domain. The registrar is needed only when new autonomic devices join the domain.
- To contact the registrar for enrolment to the autonomic domain, all new devices must have L2 reachability to at least one device that is already enrolled to the domain. If there is no L2 reachability, user needs to configure the tunnel between the devices and configure autonomic adjacency discovery on them.
- A device can be enrolled only into one autonomic domain. Two devices enrolled into different domains will not build the autonomic control plane between each other.

- Autonomic intent can be configured only on the registrar and from there it is propagated to all the devices in the domain.
- For Zero Touch Bootstrap to take place, there must be no startup-config file present and the config-register must remain default which is 0x2102.

## Restrictions for Autonomic Networking

- Autonomic networking supports only unique device identifier (UDI) -based devices.
- Autonomic networking and Zero Touch Provisioning (ZTP) are different zero touch solutions. We recommend that you do not test or use autonomic networking and ZTP at the same time.
- All the devices in an autonomic network should be contiguously autonomic. If there is no continuity, manual configuration is required to configure a tunnel through a nonautonomic network.
- In Cisco IOS XE Denali 16.3.1 Release, Cisco Catalyst 3850 and Cisco Catalyst 3650 switches support only untagged probes and channel.
- Devices running Cisco IOS XE Denali 16.3.x Release and later are not compatible with devices running releases earlier than IOS XE 3.18 or 15.6(01)T. To facilitate interwork between these devices, autonomic adjacency discovery should be configured on the interfaces.
- When autonomic networking is enabled, you must not disable IPv6 unicast routing manually.
- The autonomic Registrar functionality is not supported in Cisco Catalyst 3850 and Cisco Catalyst 3650 switches.

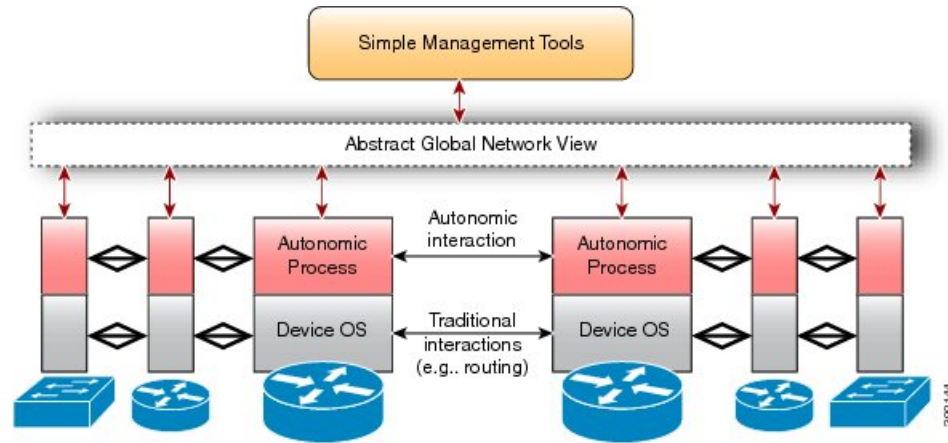
## Information About Autonomic Networking

### Overview of Autonomic Networking

The aim of autonomic networking is to create self-managing networks to overcome the rapidly growing complexity of the Internet and other networks to enable them to grow further. In a self-managing autonomic system, network management takes on a new role where, instead of controlling the network elements individually and directly, the administrator can define network-wide policies and rules to guide the self-management process.

The following figure provides a high-level architecture of an autonomic network.

Figure 145: High-Level Architecture of an Autonomic Network



Autonomic networking is controlled by a separate software entity running on top of traditional operating systems that include networking components, such as IP, Open Shortest Path First (OSPF), and so forth. Traditional networking components are unchanged and unaware of the presence of the autonomic process. The autonomic components use normal interfaces that are exposed by the traditional networking components and interact with different devices in the network. The autonomic components securely cooperate to add more intelligence to devices so that the devices in an autonomic network can autonomously configure, manage, protect, and heal themselves with minimal operator intervention. They can also securely consolidate their operations to present a simplified and abstracted view of the network to the operator.

## Autonomic Networking Infrastructure

The Autonomic Networking Infrastructure feature simplifies the network bootstrap functionality by removing the need for any kind of prestaging, thereby allowing devices to join a domain securely, after which devices can be configured. The goal of the Autonomic Networking Infrastructure feature is to make new and unconfigured devices reachable by an operator or network management system, securely. This is carried as described here:

1. A device is defined and configured as the registrar. This registrar is the first autonomic domain device.
2. This step is optional. The network administrator collects a list of legitimate device identifiers of the devices to be added to the network. This list controls the devices that are added to the autonomic domain. Devices are identified by their unique device identifier (UDI). The list is compiled as a simple text file, one UDI per line. This step is optional because, in the absence of a whitelist, all the devices are allowed to join the domain. A whitelist is an approved list of entities that is provided a particular privilege, service, mobility, access, or recognition. Whitelisting means to grant access.
3. (Optional) The whitelist of known devices is uploaded to the registrar as part of its configuration.
4. Any new autonomic device that is directly connected to the registrar, or another enrolled domain device, will automatically receive a domain certificate from the registrar.
5. The autonomic control plane is automatically established across the autonomic domain to make new devices reachable.

The benefits of Autonomic Networking Infrastructure are as follows:

- Autonomic discovery of Layer 2 topology and connectivity by discovering how to reach autonomic neighbors.
- Secure and zero touch identity of new devices by using the device name and domain certificate.
- A virtual autonomic control plane that enables communications between autonomic nodes.

Autonomic behavior is enabled by default on new devices. To enable autonomic behavior on existing devices, use the **autonomic** command. To disable, use the **no** form of this command.

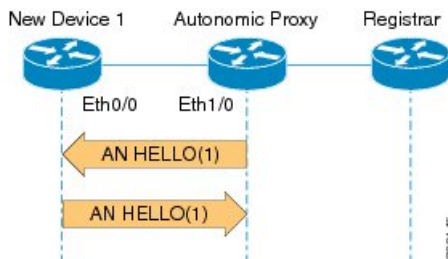
The components of autonomic networking are as follows:

- **Registrar**—A domain-specific registration authority in a given enterprise that validates new devices in the domain, provides them with domain-wide credentials, and makes policy decisions. Policy decisions can include a decision on whether a new device can join a given domain based on a preloaded whitelist. The registrar also has a database of devices that join a given domain and the device details.
- **Channel Discovery**—Used to discover reachability between autonomic nodes across nonautonomic Layer 2 networks.
- **Adjacency Discovery**—Used to discover autonomic neighbors. Adjacency discovery is performed on Layer 3. It is also possible to discover autonomic neighbors across pre-established Layer 3 Generic Routed Encapsulation (GRE) tunnels.

## New Device Joining the Autonomic Network

The following figure illustrates how a new device joins an autonomic network.

**Figure 146: New Device Joining the Autonomic Network**



1. The new device sends out a hello message to the neighbor. In this case, the neighbor is part of an autonomic network domain.
2. The hello message includes the unique device identifier (UDI) of the new device.
3. The autonomic device acts as a proxy and allows the new device to join this autonomic network domain. The autonomic network device advertises itself with the domain information to its Layer 3 neighbors.
4. On receiving the autonomic network hello message from the neighbor and detecting the UDI information, the new device is validated with the autonomic registrar.
5. The new device advertises its domain certificate in its hello message with all neighbors. The neighbor information is exchanged every 10 seconds.



**Note** If the neighbor information changes, the entry is deleted and neighbor discovery is restarted. In the absence of a domain certificate and devices working with UDI, UDI is exchanged at a 10-second interval.

## Channel Discovery in Autonomic Networking

Channel Discovery occurs automatically on all the interfaces when Autonomic Networking is enabled on the device. Note that autonomic Networking is enabled by default on devices with no configuration (greenfield devices, and assuming they have AN functionality), but will be passive. They will only be able to receive and answer CD probes, which are L2 frames. Only a device with domain certificate or one that is already enrolled to a domain can send out CD probes on all of its Ethernet interfaces that are up. As a result of this, neighbors

will be dynamically discovered. The probing will continue over time, so that newly added neighbors are discovered over time.

## Adjacency Discovery in Autonomic Networking

After a channel is established, the proxy will send ND Hello messages to the new device, that is the one that is already enrolled in the domain and can act as a proxy for a new device joining the domain. The new device will send AN Hello messages in response back to the proxy. The Hello messages consist of an identification for the new device (UDI). On receiving AN Hello messages from the new device and detecting the UDI information, the AN proxy will send the details to the Autonomic Networking Registrar (ANR) for validating this new device.

## Service Discovery in Autonomic Networking

Autonomic networking uses the multicast Domain Name System (mDNS) infrastructure to locate the various services required by the devices in the autonomic networking domain. A few of the services discovered by the network using the mDNS infrastructure are the AAA server, the configuration server, the syslog server, and the autonomic networking registrar. Autonomic networking listens to the mDNS advertisements on all the devices in the domain. From the devices hosting the services, autonomic networking initiates the mDNS advertisements.

## Autonomic Control Plane

When a new device in the domain receives a domain certificate, it exchanges the domain certificate in the Hello messages with its neighbors. This creates an autonomic control plane between two autonomic devices of the same domain. There are different types of autonomic control planes that can be created based on the different capabilities of the devices. The autonomic control plane is established by using the following mechanisms:

- Configuring a loopback interface.
- Dynamically assigning an IPv6 address to the loopback interface.
- Configuring autonomic VPN routing and forwarding (VRF).

## How to Configure Autonomic Networking

### Configuring the Registrar

#### Procedure

|               | Command or Action                                                          | Purpose                                                                                                            |
|---------------|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br>Device> enable                         | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul> |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# configure terminal | Enters global configuration mode.                                                                                  |

|                | Command or Action                                                                                                          | Purpose                                                                                                                                                                                                                                                                 |
|----------------|----------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 3</b>  | <b>autonomic</b><br><b>Example:</b><br>Device# autonomic                                                                   | Enables autonomic networking.                                                                                                                                                                                                                                           |
| <b>Step 4</b>  | <b>autonomic registrar</b><br><b>Example:</b><br>Device(config)# autonomic registrar                                       | Enables a device as a registrar and enters registrar configuration mode.<br><b>Note</b> In Cisco IOS XE Denali 16.3.1, autonomic registrar functionality is not supported for Cisco Catalyst 3850 switches and Cisco Catalyst 3650 switches.                            |
| <b>Step 5</b>  | <b>domain-id domain-name</b><br><b>Example:</b><br>Device(config-registrar)# domain-id abc.com                             | Represents a common group of all devices registered with the registrar.                                                                                                                                                                                                 |
| <b>Step 6</b>  | <b>device-accept udi</b><br><b>Example:</b><br>Device(config-registrar)# device-accept<br>PID:A901-12C-FT-D SN:CAT1902U88Y | (Optional) Specifies the UDI of a quarantined device to be accepted in the autonomic domain.<br><b>Note</b> This command is not required when configuring the registrar. It is required only after the registrar is enabled to accept previously quarantined devices.   |
| <b>Step 7</b>  | <b>whitelist filename</b><br><b>Example:</b><br>Device(config-registrar)# whitelist<br>flash:whitelist.txt                 | (Optional) Allows loading a file on the local device that contains a list of devices to be accepted in a given domain.<br>The file must contain one UDI entry per line.<br><b>Note</b> If this command is not configured, all the devices are accepted into the domain. |
| <b>Step 8</b>  | <b>no shut</b><br><b>Example:</b><br>Device(config-registrar)# no shut                                                     | Enables the autonomic registrar.                                                                                                                                                                                                                                        |
| <b>Step 9</b>  | <b>exit</b><br><b>Example:</b><br>Device(config-registrar)# exit                                                           | Exits registrar configuration mode and returns to global configuration mode.                                                                                                                                                                                            |
| <b>Step 10</b> | <b>exit</b><br><b>Example:</b><br>Device(config)# exit                                                                     | Exits global configuration mode and returns to privileged EXEC mode.                                                                                                                                                                                                    |



## Verifying and Monitoring Autonomic Networking Configuration

### Procedure

|               | Command or Action                                                                                                                                                                    | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b><br>Device> enable                                                                                                                                   | Enables privileged EXEC mode.<br><ul style="list-style-type: none"><li>• Enter your password if prompted.</li></ul>                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Step 2</b> | <b>show autonomic device</b><br><b>Example:</b><br>Device# show autonomic device                                                                                                     | Displays the current state of an autonomic device including the global details.                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Step 3</b> | <b>show autonomic neighbors [detail]</b><br><b>Example:</b><br>Device# show autonomic neighbors detail                                                                               | Displays information about the discovered neighbors.                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Step 4</b> | <b>show autonomic control-plane [detail]</b><br><b>Example:</b><br>Device# show autonomic control-plane detail                                                                       | Displays information about the autonomic control plane.                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Step 5</b> | <b>show autonomic l2-channels [detail]</b><br><b>Example:</b><br>Device# show autonomic l2-channels                                                                                  | Displays the results of Channel Discovery.                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Step 6</b> | <b>show autonomic interfaces</b><br><b>Example:</b><br>Device# show autonomic interfaces                                                                                             | Displays information about the interfaces in the autonomic domain.                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Step 7</b> | <b>debug autonomic {Bootstrap   Channel-Discovery   Infra   Intent   Neighbor-Discovery   Registrar   Services } {aaa   all   ntp   events   packets} {info   moderate   severe}</b> | Enables debugging of the autonomic network.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Step 8</b> | <b>clear autonomic {device   neighbor <i>UDI</i>   registrar accepted-device <i>device UDI</i>}</b>                                                                                  | Clears or resets autonomic information.<br><ul style="list-style-type: none"><li>• The <b>clear autonomic device</b> command clears or resets all the device-specific autonomic networking information, including the information obtained during the bootstrapping process.</li><li>• The <b>clear autonomic neighbor</b> command clears the neighbor-related information obtained during the neighbor discovery process. If no neighbor is specified, it clears the entire neighbor database.</li></ul> |

|  | Command or Action | Purpose                                                                                                                                                                                |
|--|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |                   | <ul style="list-style-type: none"><li>• The <b>clear autonomic registrar accepted-device</b> command clears the public key stored for each device enrolled by the registrar.</li></ul> |



## CHAPTER 131

# Configuring Right-To-Use Licenses

- [Finding Feature Information, on page 2445](#)
- [Restrictions for Configuring RTU Licenses, on page 2445](#)
- [Information About Configuring RTU Licenses, on page 2446](#)
- [How to Configure RTU Licenses, on page 2449](#)
- [Monitoring and Maintaining RTU Licenses, on page 2454](#)
- [Configuration Examples for RTU Licensing, on page 2455](#)
- [Additional References for RTU Licensing, on page 2459](#)
- [Feature History and Information for RTU Licensing, on page 2459](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Restrictions for Configuring RTU Licenses

The following are the restrictions for configuring and using RTU licenses.

- AP count licenses can be ordered and pre-activated on your switch.
- Imaged based licenses can be upgraded. AP count licenses can be deactivated and moved between switches and controllers.
- To activate a license, you must reboot your switch after configuring the new license level. The AP-count license does not require a reboot to activate.
- An expired evaluation license can not be reactivated after reboot.
- Stack members of a switch stack must run the same license level. If the license level is different, the switch will not join the stack until it is changed and rebooted from the active switch of the stack.

- When you downgrade the license level from an image with add-on licenses to an image without add-ons, only the base license level is retained after downgrade, and not the add-ons.

When you upgrade back to the image with the add-ons, the base license level is retained but the add-ons are not activated.

- Adder AP-count licenses are installed in the factory.

#### Related Topics

[Activating an Image Based License](#), on page 2449

[Examples: Activating RTU Image Based Licenses](#), on page 2455

## Information About Configuring RTU Licenses

### Right-To-Use Licensing

Right-to-use (RTU) licensing allows you to order and activate a specific license type and level, and then to manage license usage on your switch. The types of licenses available to order by duration are:

- Permanent licenses—For image-based licenses only. Purchased with a specific feature set with no expiration date.
- Term licenses—For add-on licenses only. Purchased with a feature set for a specific subscription period of 3, 5, or 7 years. The expiration date displays on Cisco Smart Software Manager (Cisco SSM).
- Evaluation licenses—Available with image-based and add-on licenses. Pre-installed on the switch and is valid for only a 90 day in-use period.

To activate a permanent or evaluation license, you are required to accept the End-User License Agreement (EULA).

A permanent license can be moved from one device to another. To activate a license, you must reboot your switch.

Term license expiry information is available only on Cisco SSM. To get started, create a Smart Account. Go to [software.cisco.com](http://software.cisco.com) → Administration → Request Smart Account. For more information, see: <http://www.cisco.com/c/en/us/buy/smart-accounts/software-licensing.html>

If you activate the evaluation license, it will expire in 90 days. An evaluation license is a manufacturing image on your switch and is not transferable to another switch. Once activated, this type of license cannot be deactivated until it expires. After your evaluation period expires, at the next reload your switch image will return to its default license and network operations are not impacted.

#### Related Topics

[Activating an Image Based License](#), on page 2449

[Examples: Activating RTU Image Based Licenses](#), on page 2455

### Right-To-Use Image-Based Licenses

Right-to-use image licenses support a set of features based on a specific image-based license:

- LAN Base—Layer 2 features.

- IP Base—Layer 2 and Layer 3 features.
- IP Services—Layer 2, Layer 3, and IPv6 features. (Applicable only to switches and not controllers.)

## Right-To-Use License States

After you configure a specific license type and level, you can manage your licenses by monitoring the license state.

**Table 191: RTU License States**

| License State      | Description                                                                   |
|--------------------|-------------------------------------------------------------------------------|
| Active, In Use     | EULA was accepted and the license is in use after device reboot.              |
| Active, Not In Use | EULA was accepted and the switch is ready to use when the license is enabled. |
| Not Activated      | EULA was not accepted.                                                        |

Guidelines to follow when monitoring your image based license state:

- A purchased permanent license is set to *Active, In Use* state only after a switch reboot.
- If more than one license was purchased, a reboot will activate the license with the highest feature set. For instance, the IP Services license is activated and not the LAN Base license.
- Remaining licenses purchased after switch reboot, stay in **Active, Not In Use** state.



**Note** For the AP count license, to change the state to Active, In Use, you must first make sure that the evaluation AP count license is deactivated.

## License Activation for Switch Stacks

Right-to-use licensing is supported on switch stacks. A switch is a set of up to nine stacking-capable switches connected through their StackWise-480 ports. One switch in the stack is identified as the active switch and the remaining switches are standby switches. The active switch is activated with an RTU license from its active console. The license level for the standby switches in the stack can be activated at the same time.



**Note** A switch stack cannot contain mixed license levels. Also, the switches must be of the same platform.

To change the license level, you do not need to disconnect the new added stack member if the stack cables are connected. Use the active switch console to set the new member's license level same as active switch and reboot the new member to join the stack.

## Mobility Controller Mode

AP-count licenses are used only when the switch is in Mobility Controller mode. The MC is the gatekeeper for tracking the AP-count licenses and allows an access point to join or not.

Management of AP-count licenses is performed by the in mobility controller mode configurable through the CLI.

### Related Topics

[Changing Mobility Mode](#), on page 2453

## Right-To-Use AP-Count Licensing

Right-to-use licensing (RTU) allows you to order and activate a specific license type, and then to manage license usage on your .

You can order your device with support for a specific number of adder access point count licenses, but the total number of licenses ordered should not exceed 50. You can also order your adder access point count licenses after receiving the device.

For example, if you have ordered 50 new adder licenses, you can add only those ordered adder licenses to the device. The licenses can be added in increments of 1, but the total number of licenses added for the device should not exceed 50 .

You can configure your switch to manage the access point count licenses and view the number of access points currently in use from the CLI.

The following are two different types of access point licenses:

1. Permanent licenses for the access points
  - Adder access point count license—You can purchase the adder license to increase the device capacity at a later time. You can transfer the adder access point count license from one device to another.
2. Evaluation licenses for the access points
  - You can activate these licenses to evaluate more access points before purchasing the licenses.
  - The maximum number of access points that can be evaluated is 50 .
  - The evaluation period for using the access point licenses is 90 days.
  - You can activate and deactivate the evaluation licenses from the CLI.

### Related Topics

[Activating an AP-Count License](#), on page 2451

[Obtaining an Upgrade or Capacity Adder License](#), on page 2451

[Rehosting a License](#), on page 2452

## Right-to-Use AP-Count Evaluation Licenses

If you are considering upgrading to a license with a higher access point count, you can try an evaluation license before upgrading to a permanent version of the license. For example, if you are using a permanent license

with a 50-access-point count and want to try an evaluation license with a 100-access-point count, you can try out the evaluation license for 90 days.

When an evaluation license is activated, the permanent AP-count licenses are ignored. The maximum supported licenses of 1000 access points are available for 90 days .

To prevent disruptions in operation, the device does not change licenses when an evaluation license expires. A warning expiry message is displayed daily starting five days prior to the expiry date. After 90 days, the evaluation license expires with a warning message. You must disable the evaluation license and then purchase the permanent license.

When the device reboots after the evaluation license expiry, the license defaults to a permanent license.

#### Related Topics

[Activating an AP-Count License](#), on page 2451

[Obtaining an Upgrade or Capacity Adder License](#), on page 2451

[Rehosting a License](#), on page 2452

## Right-To-Use Adder AP-Count Rehosting Licenses

Revoking a license from one device and installing it on another is called rehosting. You might want to rehost a license to change the purpose of a device. For example, if you want to move your Office Extend or indoor access points to a different device, you could transfer the adder ap-count license from one device to another.

To rehost a license, you must deactivate the adder ap-count license from one device and activate the same license on another device.

Evaluation licenses cannot be rehosted.

## How to Configure RTU Licenses

### Activating an Image Based License

To activate image based licenses, complete the following task:

#### Procedure

|               | Command or Action                                                                                                                                                                                                                  | Purpose                                                                                                                                                                                                                                                                                                              |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <pre>license right-to-use activate { ipbase   ipservices   lanbase } [ all   evaluation   slotslot-number ] [ acceptEULA ]</pre> <p><b>Example:</b></p> <pre>Device# license right-to-use activate ipservices all acceptEULA</pre> | <p>Activates the license level. Activation can happen on all switches and also include the EULA acceptance.</p> <p><b>Note</b> If you do not accept EULA, the modified configuration will not take effect after reload. The default license (or a license that was not deactivated) becomes active after reload.</p> |

|               | Command or Action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                        |        |                        |        |      |   |            |           |          |     |     |   |            |            |         |    |    |   |       |           |         |    |     |   |       |            |         |    |    |   |         |           |          |    |     |                                             |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|--------|------------------------|--------|------|---|------------|-----------|----------|-----|-----|---|------------|------------|---------|----|----|---|-------|-----------|---------|----|-----|---|-------|------------|---------|----|----|---|---------|-----------|----------|----|-----|---------------------------------------------|
| <b>Step 2</b> | <p><b>reload</b> [ <i>LINE</i>   <b>at</b>   <b>cancel</b>   <b>in</b>   <b>slot</b> <i>stack-member-number</i>   <b>standby-cpu</b> ]</p> <p><b>Example:</b></p> <pre>Device# reload slot 1 Proceed with reload? [confirm] y</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <p>Reloads a specific stack member to complete the activation process for the RTU adder AP-count license.</p> <p><b>Note</b> The reminder to accept the EULA is displayed after reload if it was not accepted earlier.</p> <p>When changing license level, you are not required to save the configuration. But, it is a good practice to ensure all the configuration is stored properly before reload. Changing from a higher license level to a lower license level on reboot will remove CLIs that are not applicable. Ensure that all features in the lower license level that are actively used are not removed.</p> |                        |        |                        |        |      |   |            |           |          |     |     |   |            |            |         |    |    |   |       |           |         |    |     |   |       |            |         |    |    |   |         |           |          |    |     |                                             |
| <b>Step 3</b> | <p><b>show license right-to-use usage</b> [ <b>slot</b> <i>slot-number</i> ]</p> <p><b>Example:</b></p> <pre>Device# show license right-to-use usage</pre> <table border="1"> <thead> <tr> <th>Slot#</th> <th>License Name</th> <th>Type</th> <th>usage-duration (y:m:d)</th> <th>In-Use</th> <th>EULA</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>ipservices</td> <td>Permanent</td> <td>0 :10:27</td> <td>yes</td> <td>yes</td> </tr> <tr> <td>1</td> <td>ipservices</td> <td>Evaluation</td> <td>0 :0 :0</td> <td>no</td> <td>no</td> </tr> <tr> <td>1</td> <td>ibase</td> <td>Permanent</td> <td>0 :0 :9</td> <td>no</td> <td>yes</td> </tr> <tr> <td>1</td> <td>ibase</td> <td>Evaluation</td> <td>0 :0 :0</td> <td>no</td> <td>no</td> </tr> <tr> <td>1</td> <td>lanbase</td> <td>Permanent</td> <td>0 :11:12</td> <td>no</td> <td>yes</td> </tr> </tbody> </table> <pre>Switch#</pre> | Slot#                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | License Name           | Type   | usage-duration (y:m:d) | In-Use | EULA | 1 | ipservices | Permanent | 0 :10:27 | yes | yes | 1 | ipservices | Evaluation | 0 :0 :0 | no | no | 1 | ibase | Permanent | 0 :0 :9 | no | yes | 1 | ibase | Evaluation | 0 :0 :0 | no | no | 1 | lanbase | Permanent | 0 :11:12 | no | yes | <p>Displays detailed usage information.</p> |
| Slot#         | License Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | usage-duration (y:m:d) | In-Use | EULA                   |        |      |   |            |           |          |     |     |   |            |            |         |    |    |   |       |           |         |    |     |   |       |            |         |    |    |   |         |           |          |    |     |                                             |
| 1             | ipservices                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Permanent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0 :10:27               | yes    | yes                    |        |      |   |            |           |          |     |     |   |            |            |         |    |    |   |       |           |         |    |     |   |       |            |         |    |    |   |         |           |          |    |     |                                             |
| 1             | ipservices                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Evaluation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0 :0 :0                | no     | no                     |        |      |   |            |           |          |     |     |   |            |            |         |    |    |   |       |           |         |    |     |   |       |            |         |    |    |   |         |           |          |    |     |                                             |
| 1             | ibase                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Permanent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0 :0 :9                | no     | yes                    |        |      |   |            |           |          |     |     |   |            |            |         |    |    |   |       |           |         |    |     |   |       |            |         |    |    |   |         |           |          |    |     |                                             |
| 1             | ibase                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Evaluation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0 :0 :0                | no     | no                     |        |      |   |            |           |          |     |     |   |            |            |         |    |    |   |       |           |         |    |     |   |       |            |         |    |    |   |         |           |          |    |     |                                             |
| 1             | lanbase                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Permanent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0 :11:12               | no     | yes                    |        |      |   |            |           |          |     |     |   |            |            |         |    |    |   |       |           |         |    |     |   |       |            |         |    |    |   |         |           |          |    |     |                                             |

### Related Topics

[Restrictions for Configuring RTU Licenses](#), on page 2445

[Right-To-Use Licensing](#), on page 2446

[Monitoring and Maintaining RTU Licenses](#), on page 2454

[Examples: Activating RTU Image Based Licenses](#), on page 2455



## Activating an AP-Count License

### Procedure

|               | Command or Action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Purpose                                                                         |                        |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|------------------------|--------|------------------------|--------|------|---|------------|-----------|------|--|--|--|--|-----|-----|--|--|---|------------|------------|------|--|--|--|--|----|----|--|--|---|--------|-----------|------|--|--|--|--|----|----|--|--|---|--------|------------|------|--|--|--|--|----|----|--|--|---|---------|-----------|------|--|--|--|--|----|----|--|--|---|---------|------------|------|--|--|--|--|----|----|--|--|---|---------|------|------|--|--|--|--|----|-----|--|--|---|---------|-------|------|--|--|--|--|-----|-----|--|--|--------------------------------------|
| <b>Step 1</b> | <p><b>license right-to-use activate</b> {<b>apcount</b> <i>ap-number</i> <b>slot</b> <i>slot-num</i>}   <b>evaluation</b>}<br/>[ <b>acceptEULA</b>]</p> <p><b>Example:</b></p> <pre>Device# license right to use activate apcount 5 slot 1 acceptEULA</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Activates one or more adder AP-count licenses and immediately accepts the EULA. |                        |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
| <b>Step 2</b> | <p><b>show license right-to-use usage</b> [ <b>slot</b> <i>slot-number</i> ]</p> <p><b>Example:</b></p> <pre>Device# show license right-to-use usage</pre> <table border="1"> <thead> <tr> <th>Slot#</th> <th>License Name</th> <th>Type</th> <th>usage-duration (y:m:d)</th> <th>In-Use</th> <th>EULA</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>ipservices</td> <td>permanent</td> <td>0 :3</td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td>yes</td> <td>yes</td> <td></td> <td></td> </tr> <tr> <td>1</td> <td>ipservices</td> <td>evaluation</td> <td>0 :0</td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td>no</td> <td>no</td> <td></td> <td></td> </tr> <tr> <td>1</td> <td>ipbase</td> <td>permanent</td> <td>0 :0</td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td>no</td> <td>no</td> <td></td> <td></td> </tr> <tr> <td>1</td> <td>ipbase</td> <td>evaluation</td> <td>0 :0</td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td>no</td> <td>no</td> <td></td> <td></td> </tr> <tr> <td>1</td> <td>lanbase</td> <td>permanent</td> <td>0 :0</td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td>no</td> <td>no</td> <td></td> <td></td> </tr> <tr> <td>1</td> <td>apcount</td> <td>evaluation</td> <td>0 :3</td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td>no</td> <td>no</td> <td></td> <td></td> </tr> <tr> <td>1</td> <td>apcount</td> <td>base</td> <td>0 :0</td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td>no</td> <td>yes</td> <td></td> <td></td> </tr> <tr> <td>1</td> <td>apcount</td> <td>adder</td> <td>0 :0</td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td>yes</td> <td>yes</td> <td></td> <td></td> </tr> </tbody> </table> <p>Switch#</p> | Slot#                                                                           | License Name           | Type   | usage-duration (y:m:d) | In-Use | EULA | 1 | ipservices | permanent | 0 :3 |  |  |  |  | yes | yes |  |  | 1 | ipservices | evaluation | 0 :0 |  |  |  |  | no | no |  |  | 1 | ipbase | permanent | 0 :0 |  |  |  |  | no | no |  |  | 1 | ipbase | evaluation | 0 :0 |  |  |  |  | no | no |  |  | 1 | lanbase | permanent | 0 :0 |  |  |  |  | no | no |  |  | 1 | apcount | evaluation | 0 :3 |  |  |  |  | no | no |  |  | 1 | apcount | base | 0 :0 |  |  |  |  | no | yes |  |  | 1 | apcount | adder | 0 :0 |  |  |  |  | yes | yes |  |  | Displays detailed usage information. |
| Slot#         | License Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Type                                                                            | usage-duration (y:m:d) | In-Use | EULA                   |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
| 1             | ipservices                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | permanent                                                                       | 0 :3                   |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | yes                                                                             | yes                    |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
| 1             | ipservices                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | evaluation                                                                      | 0 :0                   |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | no                                                                              | no                     |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
| 1             | ipbase                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | permanent                                                                       | 0 :0                   |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | no                                                                              | no                     |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
| 1             | ipbase                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | evaluation                                                                      | 0 :0                   |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | no                                                                              | no                     |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
| 1             | lanbase                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | permanent                                                                       | 0 :0                   |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | no                                                                              | no                     |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
| 1             | apcount                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | evaluation                                                                      | 0 :3                   |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | no                                                                              | no                     |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
| 1             | apcount                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | base                                                                            | 0 :0                   |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | no                                                                              | yes                    |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
| 1             | apcount                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | adder                                                                           | 0 :0                   |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | yes                                                                             | yes                    |        |                        |        |      |   |            |           |      |  |  |  |  |     |     |  |  |   |            |            |      |  |  |  |  |    |    |  |  |   |        |           |      |  |  |  |  |    |    |  |  |   |        |            |      |  |  |  |  |    |    |  |  |   |         |           |      |  |  |  |  |    |    |  |  |   |         |            |      |  |  |  |  |    |    |  |  |   |         |      |      |  |  |  |  |    |     |  |  |   |         |       |      |  |  |  |  |     |     |  |  |                                      |

### Related Topics

[Monitoring and Maintaining RTU Licenses](#), on page 2454

[Right-To-Use AP-Count Licensing](#), on page 2448

[Right-to-Use AP-Count Evaluation Licenses](#), on page 2448

## Obtaining an Upgrade or Capacity Adder License

You can use the capacity adder licenses to increase the number of access points supported by the device.

**Procedure**

|               | Command or Action                                                                                                                                                                                                                                         | Purpose                                                                         |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>license right-to-use {activate   deactivate}</b><br><b>apcount {ap-number   evaluation} slot</b><br><i>slot-num</i> [ <b>acceptEULA</b> ]<br><br><b>Example:</b><br>Device# <b>license right to use activate</b><br><b>apcount 5 slot 2 acceptEULA</b> | Activates one or more adder AP-count licenses and immediately accepts the EULA. |

**Related Topics**

[Right-to-Use AP-Count Evaluation Licenses](#), on page 2448

[Right-To-Use AP-Count Licensing](#), on page 2448

## Rehosting a License

To rehost a license, you have to deactivate the license from one device and then activate the same license on another device.

**Procedure**

|               | Command or Action                                                                                                                                                                                                                                                                                               | Purpose                                                                                                         |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>license right-to-use deactivate [license-level]</b><br><b>apcount ap-number slot slot-num</b><br><br><b>Example:</b><br>Device# <b>license right-to-use deactivate</b><br><b>apcount 1 slot 1</b><br><br><b>Example:</b><br>Device# <b>license right-to-use deactivate</b><br><b>ipbase slot 1</b><br>OR     | Deactivates the license on one device. The IP Base license level is deactivate from slot 1 in the example here. |
| <b>Step 2</b> | <b>license right-to-use activate [license-level]</b><br><b>slot slot-num [ acceptEULA ]</b><br><br><b>Example:</b><br>Device# <b>license right to use activate</b><br><b>ipbase slot 2 acceptEULA</b><br><br><b>Example:</b><br>Device# <b>license right-to-use activate</b><br><b>ipbase slot 2 acceptEULA</b> | Activates the license on another device. The IP Base license level is rehosted on slot 2 in the example here.   |

**Related Topics**

[Right-To-Use AP-Count Licensing](#), on page 2448

[Right-to-Use AP-Count Evaluation Licenses](#), on page 2448

## Changing Mobility Mode

### Procedure

|               | Command or Action                                                                                                                                                                                                                 | Purpose                                                              |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|
| <b>Step 1</b> | <b>wireless mobility controller</b><br><b>Example:</b><br><pre>Device(config)# wireless mobility controller % Mobility role changed to Mobility Controller. Please save config and reboot the whole stack.</pre>                  | Changes a switch in Mobility Agent mode to Mobility Controller mode. |
| <b>Step 2</b> | <b>write memory</b><br><b>Example:</b><br><pre>Device# write memory  Building configuration... Compressed configuration from 13870 bytes to 5390 bytes[OK] Device#</pre>                                                          |                                                                      |
| <b>Step 3</b> | <b>reload [ <i>LINE</i>   at   cancel   in   slot<br/>stack-member-number   standby-cpu ]</b><br><b>Example:</b><br><pre>Device# reload slot 3 Proceed with reload? [confirm] y</pre>                                             |                                                                      |
| <b>Step 4</b> | <b>no wireless mobility controller</b><br><b>Example:</b><br><pre>Device(config)# no wireless mobility controller % Mobility role changed to Mobility Agent. Please save config and reboot the whole stack. Switch(config)#</pre> | Changes a switch in Mobility Controller mode to Mobility Agent mode. |
| <b>Step 5</b> | <b>write memory</b><br><b>Example:</b><br><pre>Device# write memory  Building configuration... Compressed configuration from 13870 bytes to 5390 bytes[OK] Device#</pre>                                                          |                                                                      |

|               | Command or Action                                                                                                                                                                                                                     | Purpose |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| <b>Step 6</b> | <b>reload</b> [ <i>LINE</i>   <b>at</b>   <b>cancel</b>   <b>in</b>   <b>slot</b> <i>stack-member-number</i>   <b>standby-cpu</b> ]<br><br><b>Example:</b><br>Device# <b>reload slot 3</b><br>Proceed with reload? [confirm] <b>y</b> |         |

**Related Topics**

[Mobility Controller Mode](#), on page 2448

## Monitoring and Maintaining RTU Licenses

| Command                                                                                                                       | Purpose                                                                                             |
|-------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| <b>show license right-to-use default</b>                                                                                      | Displays the default license information.                                                           |
| <b>show license right-to-use detail</b>                                                                                       | Displays detailed information of all the licenses in the switch stack.                              |
| <b>show license right-to-use eula</b> {evaluation   permanent} <b>show license right-to-use eula</b> {evaluation   permanent} | Displays the end user license agreement.                                                            |
| <b>show license right-to-use mismatch</b>                                                                                     | Displays the license information that does not match.                                               |
| <b>show license right-to-use slot</b> <i>slot-number</i>                                                                      | Displays the license information for a specific slot in a switch stack.                             |
| <b>show license right-to-use summary</b>                                                                                      | Displays a summary of the license information on the entire switch stack.                           |
| <b>show license right-to-use usage</b> [ <i>slot slot-number</i> ]                                                            | Displays detailed information about usage for all licenses in the switch stack.                     |
| <b>show switch</b>                                                                                                            | Displays detailed information of every member in a switch stack including the state of the license. |

**Related Topics**

[Activating an Image Based License](#), on page 2449

[Examples: Activating RTU Image Based Licenses](#), on page 2455

[Activating an AP-Count License](#), on page 2451

# Configuration Examples for RTU Licensing

## Examples: Activating RTU Image Based Licenses

This example shows how to activate an IP Services image license and accept the EULA for a specific slot:

```
Switch# license right-to-use activate ipservices slot 1 acceptEULA
% switch-1:stack-mgr:Reboot the switch to invoke the highest activated License level
```

This example shows how to activate a license for evaluation:

```
Switch# license right-to-use activate ipservices evaluation acceptEULA
% switch-1:stack-mgr:Reboot the switch to invoke the highest activated License level
```

### Related Topics

- [Activating an Image Based License](#), on page 2449
- [Restrictions for Configuring RTU Licenses](#), on page 2445
- [Right-To-Use Licensing](#), on page 2446
- [Monitoring and Maintaining RTU Licenses](#), on page 2454

## Examples: Displaying RTU Licensing Information

This example shows the consolidated RTU licensing information from the active switch on a switch stack. All of the members in the stack have the same license level. When the evaluation AP-count license is activated, the adder AP-count licenses are ignored. The maximum number of AP-count licenses are available when evaluation is enabled.

```
Switch# show license right-to-use summary
```

| License Name | Type      | Period left |
|--------------|-----------|-------------|
| ipservices   | Permanent | Lifetime    |

```
License Level In Use: ipservices
License Level on Reboot: ipservices
```

This example shows a summary of permanent and adder licenses. The evaluation AP-count license is disabled displaying the total number of activated adder AP-count licenses in the switch stack. AP-count licenses in-use mean that they are connected.

```
Switch# show license right-to-use summary
```

| License Name | Type      | Count | Period left |
|--------------|-----------|-------|-------------|
| ipservices   | permanent | N/A   | Lifetime    |
| apcount      | base      | 0     |             |
| apcount      | adder     | 40    | Lifetime    |

```

-----
License Level In Use: ipservices
License Level on Reboot: ipservices eval
Evaluation AP-Count: Disabled
Total AP Count Licenses: 40
AP Count Licenses In-use: 10
AP Count Licenses Remaining: 30

```

This example shows the RTU default licenses. Default licenses are pre-installed and cannot be removed or transferred. If no license is activated the switch uses the default license, after a reboot.

```
Switch# show license right-to-use default
```

```

Slot#      License Name      Type
-----
      1          lanbase      Permanent
-----

```

```

Slot#      License Name      Type
-----
      2          lanbase      Permanent
-----

```

```

Slot#      License Name      Type
-----
      3          lanbase      Permanent
-----

```

This example shows the consolidated RTU licensing information of the controller. When the evaluation ap-count license is activated, the base and adder ap-count licenses are ignored. The maximum number of ap-count licenses are available when evaluation is enabled.

This example shows the RTU default licenses. Default licenses are pre-installed and cannot be removed or transferred. If no license is activated the controller uses the default license, after a reboot.

```
controller# show license right-to-use default
```

```

Slot#      License Name      Type      Count
-----
      1          apcount          base          10

```

## Example: Displaying RTU License Details

This example shows all the detailed information for the RTU licenses on slot 1:

```
Device# show license right-to-use detail slot 1
```

```

Index 1
  License Name      : ipservices
  Period left       : Lifetime
  License Type      : Permanent
  License State     : Active, In use
  License Location  : Slot 1
Index 2
  License Name      : ipservices
  Period left       : 90
  License Type      : Evaluation
  License State     : Not Activated
  License Location  : Slot 1
Index 3

```

```

License Name      : ipbase
Period left      : Lifetime
License Type     : Permanent
License State    : Active, Not In use
License Location: Slot 1
Index 4
License Name     : ipbase
Period left     : 90
License Type    : Evaluation
License State   : Not Activated
License Location: Slot 1
Index 5
License Name     : lanbase
Period left     : Lifetime
License Type    : Permanent
License State   : Active, Not In use
License Location: Slot 1

```

```

Controller# show license right-to-use detail slot 1
Index 6:  License Name: apcount
          Period left: Expired
          License Type: evaluation
          License State: Active, In use
          License Count: 1000
          License Location: Slot 1
Index 7:  License Name: apcount
          Period left: Lifetime
          License Type: base
          License State: Active, Not In use
          License Count: 0
          License Location: Slot 1
Index 8:  License Name: apcount
          Period left: Lifetime
          License Type: adder
          License State: Not Activated
          License Count: 0
          License Location: Slot 1

```

## Example: Displaying RTU License Mismatch

This example shows the license information of the switches in a stack and a mismatch state of a member switch. The member must match the active.

```

Switch# show switch

Switch/Stack Mac Address : 1c1d.8625.7700 - Local Mac Address
                               H/W   Current
Switch#  Role      Mac Address      Priority Version  State
-----
*1      Active    1c1d.8625.7700   15      V02      Ready
2       Standby   bc16.f55c.ab80   7       V04      Ready
3       Member    580a.2095.da00   1       V03      Lic-Mismatch

```



**Note** To resolve the license mismatch, first check the RTU license summary:

```
Switch# show license right-to-use
```

Then change the license level of the mismatched switched so that it is the same license level of the active switch. This example shows that the IP Base license was activated for the member switch to match the active switch.

```
Switch# license right-to-use activate ipbase slot 3 acceptEULA
```

## Example: Displaying RTU Licensing Usage

This example shows the detailed licensing usage on your switch stack. The IP Services license in Slot 1 is permanent and usage is one day. An AP-count license in Slot 2 is ready for evaluation. EULA was accepted and state shows in use, but after reboot the evaluation license will be deactivated.

```
Switch# show license right-to-use usage
```

| Slot# | License Name | Type       | usage-duration(y:m:d) | In-Use | EULA |
|-------|--------------|------------|-----------------------|--------|------|
| 1     | ipservices   | Permanent  | 0 :10:27              | yes    | yes  |
| 1     | ipservices   | Evaluation | 0 :0 :0               | no     | no   |
| 1     | ipbase       | Permanent  | 0 :0 :9               | no     | yes  |
| 1     | ipbase       | Evaluation | 0 :0 :0               | no     | no   |
| 1     | lanbase      | Permanent  | 0 :11:12              | no     | yes  |

| Slot# | License Name | Type       | usage-duration(y:m:d) | In-Use | EULA |
|-------|--------------|------------|-----------------------|--------|------|
| 2     | ipservices   | Permanent  | 0 :3 :25              | yes    | yes  |
| 2     | ipservices   | Evaluation | 0 :0 :0               | no     | no   |
| 2     | ipbase       | Permanent  | 0 :0 :0               | no     | yes  |
| 2     | ipbase       | Evaluation | 0 :0 :0               | no     | no   |
| 2     | lanbase      | Permanent  | 0 :7 :2               | no     | yes  |

| Slot# | License Name | Type       | usage-duration(y:m:d) | In-Use | EULA |
|-------|--------------|------------|-----------------------|--------|------|
| 3     | ipservices   | Permanent  | 0 :6 :15              | yes    | yes  |
| 3     | ipservices   | Evaluation | 0 :0 :0               | no     | no   |
| 3     | ipbase       | Permanent  | 0 :0 :0               | no     | yes  |
| 3     | ipbase       | Evaluation | 0 :0 :0               | no     | no   |
| 3     | lanbase      | Permanent  | 0 :8 :11              | no     | yes  |

This example shows the detailed licensing usage on your controller.

```
Controller# show license right-to-use usage
```

| Slot# | License Name | Type       | usage-duration(y:m:d) | In-Use | EULA |
|-------|--------------|------------|-----------------------|--------|------|
| 1     | apcount      | evaluation | 0 :3 :3               | yes    | yes  |



|   |         |       |         |    |     |
|---|---------|-------|---------|----|-----|
| 1 | apcount | base  | 0 :0 :0 | no | yes |
| 1 | apcount | adder | 0 :0 :0 | no | no  |

## Additional References for RTU Licensing

### Related Documents

| Related Topic                                                                    | Document Title                                                      |
|----------------------------------------------------------------------------------|---------------------------------------------------------------------|
| For complete syntax and usage information for the commands used in this chapter. | <i>System Management Command Reference (Catalyst 3850 Switches)</i> |

### Standards and RFCs

| Standard/RFC | Title |
|--------------|-------|
| None         | —     |

### MIBs

| MIB                                  | MIBs Link                                                                                                                                                                                                              |
|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| All supported MIBs for this release. | To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:<br><a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a> |

### Technical Assistance

| Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Link                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p> | <a href="http://www.cisco.com/support">http://www.cisco.com/support</a> |

## Feature History and Information for RTU Licensing

| Release            | Feature Information          |
|--------------------|------------------------------|
| Cisco IOS XE 3.2SE | This feature was introduced. |

| Release                   | Feature Information                                                                      |
|---------------------------|------------------------------------------------------------------------------------------|
| Cisco IOS XE Fuji 16.8.1a | Support for add-on licensing options (DNA Essentials and DNA Advantage) were introduced. |



## CHAPTER 132

# Configuring Administrator Usernames and Passwords

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- [Finding Feature Information, on page 2461](#)
- [Information About Configuring Administrator Usernames and Passwords, on page 2461](#)
- [Configuring Administrator Usernames and Passwords, on page 2462](#)
- [Examples: Administrator Usernames and Passwords Configuration, on page 2464](#)
- [Additional References for Administrator Usernames and Passwords, on page 2465](#)
- [Feature History and Information For Performing Administrator Usernames and Passwords Configuration, on page 2465](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Configuring Administrator Usernames and Passwords

You can configure administrator usernames and passwords to prevent unauthorized users from reconfiguring the device and viewing configuration information. This section provides instructions for initial configuration and for password recovery.

You can also set administrator usernames and passwords to manage and configure one or more access points that are associated with the device.

### Strong Passwords

You can set strong administrator passwords such as encrypted passwords with ASCII keys for the administrator user for managing access points.

Use the following guidelines while creating strong passwords:

- There should be at least three of the following categories—lowercase letters, uppercase letters, and digits, and special characters.




---

**Note** Special characters are not supported for username and password for GUI login.

---

- The new password should not be the same as that of the associated username and the username should not be reversed.
- The characters in the password should not be repeated more than three times consecutively.
- The password should not be **cisco**, **ocsic**, **admin**, **nimda**, or any variant obtained by changing the capitalization of letters therein, or by substituting "1" "|" or "!" for i, and/or substituting "0" for "o", and/or substituting "\$" for "s".
- The maximum number of characters accepted for the username and password is 32.

### Encrypted Passwords

You can set three types of keys for the password:

- Randomly generated key—This key is generated randomly and it is the most secure option. To export the configuration file from one system to another, the key should also be exported.
- Static key—The simplest option is to use a fixed (static) encryption key. By using a fixed key, no key management is required, but if the key is somehow discovered, the data can be decrypted by anyone with the knowledge of that key. This is not a secure option and it is called obfuscation in the CLI.
- User defined key—You can define the key by yourself. To export the configuration file from one system to another, both systems should have the same key configured.




---

**Note** When you configure the **ap mgmtuser username** and **ap dot1x username** commands, the system encrypts the password automatically when password encryption aes is enabled and the encryption key is configured with the **key config-key password-encrypt** command. If an already-encrypted password is entered (that is, type 8), then it must be one that has been encrypted with the currently stored key. If the key of the encrypted password does not match the currently stored key, the encrypted password is rejected. In such case, you can enter the password in plain text (that is, type 0) and allow the system to encrypt it automatically.

---

## Configuring Administrator Usernames and Passwords

### Procedure

|               | Command or Action                                                                     | Purpose                           |
|---------------|---------------------------------------------------------------------------------------|-----------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><br><b>Example:</b><br>Device# <b>configure terminal</b> | Enters global configuration mode. |

|        | Command or Action                                                                                                                                                                                                                                                          | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Step 2 | <b>wireless security strong-password</b><br><b>Example:</b><br>Device(config)# <b>wireless security strong-password</b>                                                                                                                                                    | Enables strong password policy for the administrator user.                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Step 3 | <b>username admin-username password {0 unencrypted_password   7 hidden_password   unencrypted_text}</b><br><b>Example:</b><br>Device(config)# <b>username adminuser1 password 0 QZsek239@</b>                                                                              | Specifies a username and password for an administrator.<br><br>The administrator can configure the device and view the configured information.                                                                                                                                                                                                                                                                                                                                                                                         |
| Step 4 | <b>username admin-username secret {0 unencrypted_secret_text   4 SHA256 encrypted_secret_text   5 MD5 encrypted_secret_text   LINE}</b><br><b>Example:</b><br>Device(config)# <b>username adminuser1 secret 0 QZsek239@</b>                                                | Specifies the secret for the administrator.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Step 5 | <b>ap mgmtuser username username password {0 unencrypted_password   8 AES encrypted password }secret {0 unencrypted_password   8 AES encrypted password }</b><br><b>Example:</b><br>Device(config)# <b>ap mgmtuser username cisco password 0 Qwci12@ secret 0 Qwci14@!</b> | Specifies administrator username and password for managing all of the access points configured to the device.<br><br>You can also include the secret text to perform privileged access point management.<br><br><b>Note</b> If your password is not strong enough to fulfill the strong password policy, then the password is rejected with a valid error message. For example, the following password is rejected because it is not a strong password.<br><br>Device# <b>ap mgmtuser username cisco password 0 abcd secret 0 1234</b> |
| Step 6 | <b>ap dot1x username username password {0 unencrypted_password   8 AES encrypted password }</b><br><b>Example:</b><br>Device(config)# <b>ap dot1x username cisco password 0 Qwci12@</b>                                                                                    | Specifies the 802.1X username and password for managing all of the access points configured to the device.                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Step 7 | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b>                                                                                                                                                                                                                | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                                                                                                                                                                                                                                                                                                                                                                    |

|               | Command or Action                                                                                                                                                                                                                                                                | Purpose                                                                                                                                 |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 8</b> | <p><b>ap name</b> <i>apname</i> <b>mgmtuser</b> <i>username</i> <b>username</b> <i>password</i> <b>password</b> <b>secret</b> <i>secret_text</i></p> <p><b>Example:</b></p> <pre>Device# ap name APf0f7.55c7.7b23 mgmtuser username cisco password Qne35! secret Nzep592\$</pre> | Configures the administrator username, password, and secret text for managing a specific access point that is configured to the device. |
| <b>Step 9</b> | <p><b>ap name</b> <i>apname</i> <b>dot1x-user</b> <i>username</i> <b>password</b> <i>password</i></p> <p><b>Example:</b></p> <pre>Device# ap name APf0f7.55c7.7b23 dot1x-user username cisco password Qne35!</pre>                                                               | Configures the 802.1X username and password for a specific access point.                                                                |

**Example**

## Examples: Administrator Usernames and Passwords Configuration

This example shows how to configure administrator usernames and passwords with the strong password policy in configuration mode:

```
Device# configure terminal
Device(config)# wireless security strong-password
Device(config)# username adminuser1 password 0 QZsek239@
Device(config)# ap mgmtuser username cisco password 0 Qwci12@ secret 0 Qwci14@!
Device(config)# ap dot1x username cisco password 0 Qwci12@
Device# end
```

This example shows how to configure administrator usernames and passwords for an access point in global EXEC mode:

```
Device# wireless security strong-password
Device# ap name APf0f7.55c7.7b23 mgmtuser username cisco password Qwci12@ secret Qwci14@
Device# ap name APf0f7.55c7.7b23 dot1x-user username cisco password Qwci12@
Device# end
```

# Additional References for Administrator Usernames and Passwords

## Related Documents

| Related Topic              | Document Title                                                                                      |
|----------------------------|-----------------------------------------------------------------------------------------------------|
| System management commands | <i>System Management Command Reference Guide (Cisco IOS XE Release 3SE (Cisco WLC 5700 Series))</i> |

## Standards and RFCs

| Standard/RFC | Title |
|--------------|-------|
| None         | —     |

## MIBs

| MIB                                      | MIBs Link                                                                                                                                                                                                                  |
|------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| All the supported MIBs for this release. | To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:<br><br><a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a> |

## Technical Assistance

| Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Link                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p> | <a href="http://www.cisco.com/support">http://www.cisco.com/support</a> |

# Feature History and Information For Performing Administrator Usernames and Passwords Configuration

| Release            | Feature Information          |
|--------------------|------------------------------|
| Cisco IOS XE 3.2SE | This feature was introduced. |







## CHAPTER 133

# 802.11 parameters and Band Selection

- [Finding Feature Information, on page 2467](#)
- [Restrictions on Band Selection, 802.11 Bands, and Parameters, on page 2467](#)
- [Information About Configuring Band Selection, 802.11 Bands, and Parameters, on page 2468](#)
- [How to Configure 802.11 Bands and Parameters, on page 2470](#)
- [Monitoring Configuration Settings for Band Selection, 802.11 Bands, and Parameters, on page 2476](#)
- [Configuration Examples for Band Selection, 802.11 Bands, and Parameters, on page 2480](#)
- [Additional References for 802.11 Parameters and Band Selection, on page 2482](#)
- [Feature History and Information For Performing 802.11 parameters and Band Selection Configuration, on page 2483](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Restrictions on Band Selection, 802.11 Bands, and Parameters

- Band selection-enabled WLANs do not support time-sensitive applications such as voice and video because of roaming delays.
- Band selection can be used only with Cisco Aironet 1140, 1250, 1260, 1550, 1800, 2600, 2800, 3500, 3600, 3800 Series access points.
- Mid-RSSI is not supported on Cisco Aironet 1600 Series access points.
- Band selection is not supported in Cisco Aironet 1040, OEAP 600 Series access points.
- Band selection operates only on access points that are connected to a controller. A FlexConnect access point without a controller connection does not perform band selection after a reboot.

- The band-selection algorithm directs dual-band clients only from the 2.4-GHz radio to the 5-GHz radio of the same access point, and it only runs on an access point when both the 2.4-GHz and 5-GHz radios are up and running.
- You can enable both band selection and aggressive load balancing on the controller. They run independently and do not impact one another.
- It is not possible to enable or disable band selection and client load balancing globally through the controller GUI or CLI. You can, however, enable or disable band selection and client load balancing for a particular WLAN. Band selection and client load balancing are enabled globally by default.

## Information About Configuring Band Selection, 802.11 Bands, and Parameters

### Band Selection

Band selection enables client radios that are capable of dual-band (2.4 and 5-GHz) operations to move to a less congested 5-GHz access point. The 2.4-GHz band is often congested. Clients on this band typically experience interference from Bluetooth devices, microwave ovens, and cordless phones as well as co-channel interference from other access points because of the 802.11b/g limit of 3 nonoverlapping channels. To prevent these sources of interference and improve overall network performance, configure band selection on the device.

Band selection works by regulating probe responses to clients and it can be enabled on a per-WLAN basis. It makes 5-GHz channels more attractive to clients by delaying probe responses to clients on 2.4-GHz channels. In an access point, the band select table can be viewed by running the **show dot11 band-select** command. It can also be viewed by running the **show cont d0/d1 | begin Lrucommand**.



---

**Note** The WMM default configuration is not shown in the **show running-config** command output.

---

### Band Selection Algorithm

The band selection algorithm affects clients that use 2.4-GHz band. Initially, when a client sends a probe request to an access point, the corresponding client probe's Active and Count values (as seen from the band select table) become 1. The algorithm functions based on the following scenarios:

- Scenario 1—Client RSSI (as seen from the **show cont d0/d1 | begin RSSI** command output) is greater than both Mid RSSI and Acceptable Client RSSI.
  - Dual-band clients—No 2.4-GHz probe responses are seen at any time; 5-GHz probe responses are seen for all 5-GHz probe requests.
  - Single-band (2.4-GHz) clients—2.4-GHz probe responses are seen only after the probe suppression cycle.
  - After the client's probe count reaches the configured probe cycle count, the algorithm waits for the Age Out Suppression time and then marks the client probe's Active value as 0. Then, the algorithm is restarted.

- Scenario2—Client RSSI (as seen from **show cont d0/d1 | begin RSSI**) lies between Mid-RSSI and Acceptable Client RSSI.
  - All 2.4-GHz and 5-GHz probe requests are responded to without any restrictions.
  - This scenario is similar to the band select disabled.



---

**Note** The client RSSI value (as seen in the **sh cont d0 | begin RSSI** command output) is the average of the client packets received, and the Mid RSSI feature is the instantaneous RSSI value of the probe packets. As a result, the client RSSI is seen as weaker than the configured Mid RSSI value (7-dB delta). The 802.11b probes from the client are suppressed to push the client to associate with the 802.11a band.

---

## 802.11 Bands

You can configure the 802.11b/g/n (2.4 GHz) and 802.11a/n (5 GHz) bands for the controller to comply with the regulatory requirements in your country. By default, both 802.11b/g/n and 802.11a/n are enabled.

When a controller is configured to allow only 802.11g traffic, 802.11b client devices are able to successfully connect to an access point, but cannot pass traffic. When you configure the controller only for 802.11g traffic, you must mark 11g rates as mandatory.



---

**Note** The Block Acks in a Cisco 2800, 3800, 1560 APs are sent at configured mandatory data rates in Cisco WLC for 2.4 GHz radio.

---

## 802.11n Parameters

This section provides instructions for managing 802.11n access points on your network. The 802.11n devices support the 2.4 and 5-GHz bands and offer high throughput data rates.

The 802.11n high throughput rates are available on all the 802.11n access points for the WLANs using WMM with no Layer 2 encryption or with WPA2/AES encryption enabled.



---

**Note** Some Cisco 802.11n APs may intermittently emit incorrect beacon frames, which can trigger false WIPS alarms. We recommend that you ignore these alarms. The issue is observed in the following Cisco 802.11n APs: 1140, 1250, 2600, 3500, and 3600.

---

## 802.11h Parameters

802.11h informs client devices about channel changes and can limit the transmit power of those client devices.

# How to Configure 802.11 Bands and Parameters

## Configuring Band Selection (CLI)

### Procedure

|               | Command or Action                                                                                                                                                                 | Purpose                                                                                                                |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><br><b>Example:</b><br>Device# <code>configure terminal</code>                                                                                       | Enters global configuration mode.                                                                                      |
| <b>Step 2</b> | <b>wireless client band-select cycle-count</b><br><i>cycle_count</i><br><br><b>Example:</b><br>Device(config)# <code>wireless client band-select cycle-count 3</code>             | Sets the probe cycle count for band select.<br>Valid range is between 1 and 10.                                        |
| <b>Step 3</b> | <b>wireless client band-select cycle-threshold</b><br><i>milliseconds</i><br><br><b>Example:</b><br>Device(config)# <code>wireless client band-select cycle-threshold 5000</code> | Sets the time threshold for a new scanning cycle period.<br>Valid range is between 1 and 1000.                         |
| <b>Step 4</b> | <b>wireless client band-select expire suppression</b><br><i>seconds</i><br><br><b>Example:</b><br>Device(config)# <code>wireless client band-select expire suppression 100</code> | Sets the suppression expire to the band select.<br>Valid range is between 10 and 200.                                  |
| <b>Step 5</b> | <b>wireless client band-select expire dual-band</b><br><i>seconds</i><br><br><b>Example:</b><br>Device(config)# <code>wireless client band-select expire dual-band 100</code>     | Sets the dual band expire.<br>Valid range is between 10 and 300.                                                       |
| <b>Step 6</b> | <b>wireless client band-select client-rssi</b><br><i>client_rssi</i><br><br><b>Example:</b><br>Device(config)# <code>wireless client band-select client-rssi 40</code>            | Sets the client RSSI threshold.<br>Valid range is between 20 and 90.                                                   |
| <b>Step 7</b> | <b>end</b><br><br><b>Example:</b><br>Device(config)# <code>end</code>                                                                                                             | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

|               | Command or Action                                                                                                                                                                                                     | Purpose                                                                                                                                                                     |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 8</b> | <b>wlan</b> <i>wlan_profile_name</i> <i>wlan_ID</i><br><i>SSID_network_name</i> <b>band-select</b><br><br><b>Example:</b><br>Device(config) # <b>wlan wlan1 25 ssid12</b><br>Device(config-wlan) # <b>band-select</b> | Configures band selection on specific WLANs.<br>Valid range is between 1 and 512.<br>You can enter up to 32 alphanumeric characters for <i>SSID_network_name</i> parameter. |
| <b>Step 9</b> | <b>end</b><br><br><b>Example:</b><br>Device(config) # <b>end</b>                                                                                                                                                      | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                      |

## Configuring the 802.11 Bands (CLI)

Follow the procedure given below to configure 802.11 bands and parameters:

### Procedure

|               | Command or Action                                                                                                                                            | Purpose                                                                                                                                                                                                                                                      |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                                        | Enters global configuration mode.                                                                                                                                                                                                                            |
| <b>Step 2</b> | <b>ap dot11 5ghz shutdown</b><br><br><b>Example:</b><br>Device(config) # <b>ap dot11 5ghz shutdown</b>                                                       | Disables the 802.11a band.<br><br><b>Note</b> You must disable the 802.11a band before configuring the 802.11a network parameters.                                                                                                                           |
| <b>Step 3</b> | <b>ap dot11 24ghz shutdown</b><br><br><b>Example:</b><br>Device(config) # <b>ap dot11 24ghz shutdown</b>                                                     | Disables the 802.11b band.<br><br><b>Note</b> You must disable the 802.11b band before configuring the 802.11b network parameters.                                                                                                                           |
| <b>Step 4</b> | <b>ap dot11 {5ghz   24ghz} beaconperiod</b><br><i>time_unit</i><br><br><b>Example:</b><br>Device(config) # <b>ap dot11 5ghz</b><br><b>beaconperiod 500</b>   | Specifies the rate at which the SSID is broadcast by the corresponding access point.<br>The beacon interval is measured in time units (TUs). One TU is 1024 microseconds. You can configure the access point to send a beacon every 20 to 1000 milliseconds. |
| <b>Step 5</b> | <b>ap dot11 {5ghz   24ghz} fragmentation</b><br><i>threshold</i><br><br><b>Example:</b><br>Device(config) # <b>ap dot11 5ghz</b><br><b>fragmentation 300</b> | Specifies the size at which packets are fragmented.<br>The threshold is a value between 256 and 2346 bytes (inclusive). Specify a low number for                                                                                                             |

|               | Command or Action                                                                                                                                                                     | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               |                                                                                                                                                                                       | areas where communication is poor or where there is a great deal of radio interference.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Step 6</b> | <b>ap dot11 {5ghz   24ghz} dtpc</b><br><b>Example:</b><br>Device (config) # <b>ap dot11 5ghz dtpc</b><br>Device (config) # <b>no ap dot11 24ghz dtpc</b>                              | <p>Enables access points to advertise their channels and transmit the power levels in beacons and probe responses.</p> <p>The default value is enabled. Client devices using dynamic transmit power control (DTPC) receive the channel-level and power-level information from the access points and adjust their settings automatically. For example, a client device used primarily in Japan can rely on DTTPC to adjust its channel and power settings automatically when it travels to Italy and joins a network there.</p> <p>The <b>no</b> form of the command disables the 802.11a or 802.11b DTTPC setting.</p>                                                                                                                                                                                          |
| <b>Step 7</b> | <b>wireless client association limit <i>number</i> interval <i>milliseconds</i></b><br><b>Example:</b><br>Device (config) # <b>wireless client association limit 50 interval 1000</b> | <p>Specifies the maximum allowed clients that can be configured.</p> <p>You can configure the maximum number of association requests on a single access point slot at a given interval. The range of association limit that you can configure is from 1 to 100.</p> <p>The association request limit interval is measured between 100 to 10000 milliseconds.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Step 8</b> | <b>ap dot11 {5ghz   24ghz} rate <i>rate</i> {disable   mandatory   supported}</b><br><b>Example:</b><br>Device (config) # <b>ap dot11 5ghz rate 36 mandatory</b>                      | <p>Specifies the rate at which data can be transmitted between the controller and the client.</p> <ul style="list-style-type: none"> <li>• <i>disable</i>—Defines that the clients specify the data rates used for communication.</li> <li>• <i>mandatory</i>—Defines that the clients support this data rate in order to associate to an access point on the controller.</li> <li>• <i>supported</i>—Any associated clients that support this data rate can communicate with the access point using that rate. However, the clients are not required to use this rate in order to associate.</li> <li>• <i>rate</i>—Specifies the rate at which data is transmitted. For the 802.11a and 802.11b bands, the data is transmitted at the rate of 1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48, or 54 Mbps.</li> </ul> |

|                | Command or Action                                                                                         | Purpose                                                                                                                                                                                                                       |
|----------------|-----------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 9</b>  | <b>no ap dot11 5ghz shutdown</b><br><b>Example:</b><br>Device(config)# <b>no ap dot11 5ghz shutdown</b>   | Enables the 802.11a band.<br><b>Note</b> The default value is enabled.                                                                                                                                                        |
| <b>Step 10</b> | <b>no ap dot11 24ghz shutdown</b><br><b>Example:</b><br>Device(config)# <b>no ap dot11 24ghz shutdown</b> | Enables the 802.11b band.<br><b>Note</b> The default value is enabled.                                                                                                                                                        |
| <b>Step 11</b> | <b>ap dot11 24ghz dot11g</b><br><b>Example:</b><br>Device(config)# <b>ap dot11 24ghz dot11g</b>           | Enables or disables 802.11g network support.<br>The default value is enabled. You can use this command only if the 802.11b band is enabled. If you disable this feature, the 802.11b band is enabled without 802.11g support. |
| <b>Step 12</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b>                                               | Returns to privileged EXEC mode.                                                                                                                                                                                              |

## Configuring 802.11n Parameters (CLI)

### Procedure

|               | Command or Action                                                                                                                   | Purpose                                                                                                                                                                                                                                                                |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                   | Enters global configuration mode.                                                                                                                                                                                                                                      |
| <b>Step 2</b> | <b>ap dot11 {5ghz   24ghz} dot11n</b><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz dot11n</b>                             | Enables 802.11n support on the network.<br>The <b>no</b> form of this command disables the 802.11n support on the network.                                                                                                                                             |
| <b>Step 3</b> | <b>ap dot11 {5ghz   24ghz} dot11n mcs tx <i>rtu</i></b><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz dot11n mcs tx 20</b> | Specifies the modulation and coding scheme (MCS) rates at which data can be transmitted between the access point and the client.<br><i>rtu</i> -The valid range is between 0 and 23.<br>The <b>no</b> form of this command disables the MCS rates that are configured. |
| <b>Step 4</b> | <b>wlan <i>wlan_profile_name</i> <i>wlan_ID</i> <i>SSID_network_name</i> wmm require</b><br><b>Example:</b>                         | Enables WMM on the WLAN and uses the 802.11n data rates that you configured.                                                                                                                                                                                           |

|               | Command or Action                                                                                                                                                                    | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | <pre>Device(config)# wlan wlan1 25 ssid12 Device(config-wlan)# wmm require</pre>                                                                                                     | The <b>require</b> keyword requires client devices to use WMM. Devices that do not support WMM cannot join the WLAN.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Step 5</b> | <p><b>ap dot11 {5ghz   24ghz} shutdown</b></p> <p><b>Example:</b></p> <pre>Device(config)# ap dot11 5ghz shutdown</pre>                                                              | Disables the network.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Step 6</b> | <p><b>{ap   no ap} dot11 {5ghz   24 ghz} dot11n a-mpdu tx priority {all   0-7}</b></p> <p><b>Example:</b></p> <pre>Device(config)# ap dot11 5ghz dot11n a-mpdu tx priority all</pre> | <p>Specifies the aggregation method used for 802.11n packets.</p> <p>Aggregation is the process of grouping packet data frames together, rather than transmitting them separately. Two aggregation methods are available: Aggregated MAC Protocol Data Unit (A-MPDU) and Aggregated MAC Service Data Unit (A-MSDU). Both A-MPDU and A-MSDU are performed in the software.</p> <p>You can specify the aggregation method for various types of traffic from the access point to the clients.</p> <p>The list defines the priority levels (0-7) assigned per traffic type.</p> <ul style="list-style-type: none"> <li>• 0—Best effort</li> <li>• 1—Background</li> <li>• 2—Spare</li> <li>• 3—Excellent effort</li> <li>• 4—Controlled load</li> <li>• 5—Video, less than 100-ms latency and jitter</li> <li>• 6—Voice, less than 100-ms latency and jitter</li> <li>• 7—Network control</li> </ul> <p>You can configure each priority level independently, or you can use the all the parameters to configure all the priority levels at once. You can configure priority levels so that the traffic uses either A-MPDU transmission or A-MSDU transmission.</p> <ul style="list-style-type: none"> <li>• When you use the <b>ap</b> command along with the other options, the traffic associated with that priority level uses A-MPDU transmission.</li> </ul> |



|                | Command or Action                                                                                                                                       | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                |                                                                                                                                                         | <ul style="list-style-type: none"> <li>When you use the <b>no ap</b> command along with the other options, the traffic associated with that priority level uses A-MSDU transmission.</li> </ul> <p>Configure the priority levels to match the aggregation method used by the clients. By default, A-MPDU is enabled for priority level 0, 4, and 5, and the rest are disabled. By default, A-MPDU is enabled for all priorities except 6 and 7.</p> |
| <b>Step 7</b>  | <b>no ap dot11 {5ghz   24ghz} shutdown</b><br><b>Example:</b><br>Device(config)# <b>no ap dot11 5ghz shutdown</b>                                       | Re-enables the network.                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Step 8</b>  | <b>ap dot11 {5ghz   24ghz} dot11n guard-interval {any   long}</b><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz dot11n guard-interval long</b> | Configures the guard interval for the network.                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Step 9</b>  | <b>ap dot11 {5ghz   24ghz} dot11n rifs rx</b><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz dot11n rifs rx</b>                                 | Configures the Reduced Interframe Space (RIFS) for the network.                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Step 10</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b>                                                                                             | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                                                                                                                                                                                                                                                                                 |

## Configuring 802.11h Parameters (CLI)

### Procedure

|               | Command or Action                                                                                 | Purpose                                                                                                                                                                                           |
|---------------|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>ap dot11 5ghz shutdown</b><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz shutdown</b> | Disables the 802.11a network.                                                                                                                                                                     |
| <b>Step 2</b> | <b>{ap   no ap} dot11 5ghz channelswitch mode switch_mode</b><br><b>Example:</b>                  | Enables or disables the access point to announce when it is switching to a new channel.<br><br><i>switch_mode</i> --Enter 0 or 1 to specify whether transmissions are restricted until the actual |

|               | Command or Action                                                                                                               | Purpose                                                                                                                |
|---------------|---------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
|               | Device(config)# <b>ap dot11 5ghz channelswitch mode 0</b>                                                                       | channel switch (0) or are not restricted (1). The default value is disabled.                                           |
| <b>Step 3</b> | <b>ap dot11 5ghz power-constraint value</b><br><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz power-constraint 200</b> | Configures the 802.11h power constraint value in dB. The valid range is from 0 to 255.<br><br>The default value is 3.  |
| <b>Step 4</b> | <b>no ap dot11 5ghz shutdown</b><br><br><b>Example:</b><br>Device(config)# <b>no ap dot11 5ghz shutdown</b>                     | Re-enables the 802.11a network.                                                                                        |
| <b>Step 5</b> | <b>end</b><br><br><b>Example:</b><br>Device(config)# <b>end</b>                                                                 | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

## Monitoring Configuration Settings for Band Selection, 802.11 Bands, and Parameters

### Verifying Configuration Settings Using Band Selection and 802.11 Bands Commands

The following commands can be used to verify band selection, 802.11 bands, and parameters on the .

*Table 192: Monitoring Configuration Settings Using Band Selection and 802.11 Band Commands*

| Command                            | Purpose                                                                                                                      |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| <b>show ap dot11 5ghz network</b>  | Displays 802.11a band network parameters, 802.11a operational rates, 802.11n MCS settings, and 802.11n status information.   |
| <b>show ap dot11 24ghz network</b> | Displays 802.11b band network parameters, 802.11b/g operational rates, 802.11n MCS settings, and 802.11n status information. |
| <b>show wireless dot11h</b>        | Displays 802.11h configuration parameters.                                                                                   |
| <b>show wireless band-select</b>   | Displays band-select configuration settings.                                                                                 |

### Example: Viewing the Configuration Settings for the 5-GHz Band

```
Device# show ap dot11 5ghz network
802.11a Network : Enabled
11nSupport : Enabled
```

```
802.11a Low Band : Enabled
802.11a Mid Band : Enabled
802.11a High Band : Enabled

802.11a Operational Rates
802.11a 6M : Mandatory
802.11a 9M : Supported
802.11a 12M : Mandatory
802.11a 18M : Supported
802.11a 24M : Mandatory
802.11a 36M : Supported
802.11a 48M : Supported
802.11a 54M : Supported
802.11n MCS Settings:
MCS 0 : Supported
MCS 1 : Supported
MCS 2 : Supported
MCS 3 : Supported
MCS 4 : Supported
MCS 5 : Supported
MCS 6 : Supported
MCS 7 : Supported
MCS 8 : Supported
MCS 9 : Supported
MCS 10 : Supported
MCS 11 : Supported
MCS 12 : Supported
MCS 13 : Supported
MCS 14 : Supported
MCS 15 : Supported
MCS 16 : Supported
MCS 17 : Supported
MCS 18 : Supported
MCS 19 : Supported
MCS 20 : Supported
MCS 21 : Supported
MCS 22 : Supported
MCS 23 : Supported
802.11n Status:
A-MPDU Tx:
  Priority 0 : Enabled
  Priority 1 : Disabled
  Priority 2 : Disabled
  Priority 3 : Disabled
  Priority 4 : Enabled
  Priority 5 : Enabled
  Priority 6 : Disabled
  Priority 7 : Disabled
A-MSDU Tx:
  Priority 0 : Enabled
  Priority 1 : Enabled
  Priority 2 : Enabled
  Priority 3 : Enabled
  Priority 4 : Enabled
  Priority 5 : Enabled
  Priority 6 : Disabled
  Priority 7 : Disabled
Guard Interval : Any
Rifs Rx : Enabled
Beacon Interval : 100
CF Pollable mandatory : Disabled
CF Poll Request Mandatory : Disabled
CFP Period : 4
CFP Maximum Duration : 60
```

**Example: Viewing the Configuration Settings for the 24-GHz Band**

```

Default Channel : 36
Default Tx Power Level : 1
DTPC Status : Enabled
Fragmentation Threshold : 2346
Pico-Cell Status : Disabled
Pico-Cell-V2 Status : Disabled
TI Threshold : 0
Legacy Tx Beamforming setting : Disabled
Traffic Stream Metrics Status : Disabled
Expedited BW Request Status : Disabled
EDCA profile type check : default-wmm
Call Admission Control (CAC) configuration
Voice AC
  Voice AC - Admission control (ACM) : Disabled
  Voice Stream-Size : 84000
  Voice Max-Streams : 2
  Voice Max RF Bandwidth : 75
  Voice Reserved Roaming Bandwidth : 6
  Voice Load-Based CAC mode : Enabled
  Voice tspec inactivity timeout : Enabled
CAC SIP-Voice configuration
  SIP based CAC : Disabled
  SIP Codec Type : CODEC_TYPE_G711
  SIP call bandwidth : 64
  SIP call bandwidth sample-size : 20
Video AC
  Video AC - Admission control (ACM) : Disabled
  Video max RF bandwidth : Infinite
  Video reserved roaming bandwidth : 0

```

**Example: Viewing the Configuration Settings for the 24-GHz Band**

```

Device# show ap dot11 24ghz network
802.11b Network : Enabled
11gSupport : Enabled
11nSupport : Enabled

802.11b/g Operational Rates
802.11b 1M : Mandatory
802.11b 2M : Mandatory
802.11b 5.5M : Mandatory
802.11g 6M : Supported
802.11g 9M : Supported
802.11b 11M : Mandatory
802.11g 12M : Supported
802.11g 18M : Supported
802.11g 24M : Supported
802.11g 36M : Supported
802.11g 48M : Supported
802.11g 54M : Supported
802.11n MCS Settings:
MCS 0 : Supported
MCS 1 : Supported
MCS 2 : Supported
MCS 3 : Supported
MCS 4 : Supported
MCS 5 : Supported
MCS 6 : Supported
MCS 7 : Supported
MCS 8 : Supported
MCS 9 : Supported
MCS 10 : Supported

```

```
MCS 11 : Supported
MCS 12 : Supported
MCS 13 : Supported
MCS 14 : Supported
MCS 15 : Supported
MCS 16 : Supported
MCS 17 : Supported
MCS 18 : Supported
MCS 19 : Supported
MCS 20 : Supported
MCS 21 : Supported
MCS 22 : Supported
MCS 23 : Supported
802.11n Status:
A-MPDU Tx:
  Priority 0 : Enabled
  Priority 1 : Disabled
  Priority 2 : Disabled
  Priority 3 : Disabled
  Priority 4 : Enabled
  Priority 5 : Enabled
  Priority 6 : Disabled
  Priority 7 : Disabled
A-MSDU Tx:
  Priority 0 : Enabled
  Priority 1 : Enabled
  Priority 2 : Enabled
  Priority 3 : Enabled
  Priority 4 : Enabled
  Priority 5 : Enabled
  Priority 6 : Disabled
  Priority 7 : Disabled
Guard Interval : Any
Rifs Rx : Enabled
Beacon Interval : 100
CF Pollable Mandatory : Disabled
CF Poll Request Mandatory : Disabled
CFP Period : 4
CFP Maximum Duration : 60
Default Channel : 11
Default Tx Power Level : 1
DTPC Status : true
Call Admission Limit : 105
G711 CU Quantum : 15
ED Threshold : -50
Fragmentation Threshold : 2346
PBCC Mandatory : Disabled
Pico-Cell Status : Disabled
Pico-Cell-V2 Status : Disabled
RTS Threshold : 2347
Short Preamble Mandatory : Enabled
Short Retry Limit : 7
Legacy Tx Beamforming setting : Disabled
Traffic Stream Metrics Status : Disabled
Expedited BW Request Status : Disabled
EDCA profile type : default-wmm
Call Admission Control (CAC) configuration
Voice AC
  Voice AC - Admission control (ACM) : Disabled
  Voice Stream-Size : 84000
  Voice Max-Streams : 2
  Voice Max RF Bandwidth : 75
  Voice Reserved Roaming Bandwidth : 6
  Voice Load-Based CAC mode : Enabled
```

```

    Voice tspec inactivity timeout : Enabled
CAC SIP-Voice configuration
  SIP based CAC : Disabled
  SIP Codec Type : CODEC_TYPE_G711
  SIP call bandwidth : 64
  SIP call bandwidth sample-size : 20
Video AC
  Video AC - Admission control (ACM) : Disabled
  Video max RF bandwidth : Infinite
  Video reserved roaming bandwidth : 0

```

## Example: Viewing the status of 802.11h Parameters

```

Device# show wireless dot11h
Power Constraint: 0
Channel Switch: 0
Channel Switch Mode: 0

```

## Example: Verifying the Band-Selection Settings

The following example displays a band-select configuration:

```

Device# show wireless band-select

Band Select Probe Response : per WLAN enabling
Cycle Count                : 2
Cycle Threshold (millisec) : 200
Age Out Suppression (sec)  : 20
Age Out Dual Band (sec)   : 60
Client RSSI (dBm)         : -80
Client Mid RSSI (dBm)     : -80

```

# Configuration Examples for Band Selection, 802.11 Bands, and Parameters

## Examples: Band Selection Configuration

This example shows how to set the probe cycle count and time threshold for a new scanning cycle period for band select:

```

Device# configure terminal
Device(config)# wireless client band-select cycle-count 3
Device(config)# wireless client band-select cycle-threshold 5000
Device(config)# end

```

This example shows how to set the suppression expiry time to the band select:

```

Device# configure terminal
Device(config)# wireless client band-select expire suppression 100
Device(config)# end

```

This example shows how to set the dual-band expiry time for the band select:

```
Device# configure terminal
Device(config)# wireless client band-select expire dual-band 100
Device(config)# end
```

This example shows how to set the client RSSI threshold for the band select:

```
Device# configure terminal
Device(config)# wireless client band-select client-rssi 40
Device(config)# end
```

This example shows how to configure band selection on specific WLANs:

```
Device# configure terminal
Device(config)# wlan wlan1 25 ssid12
Device(config-wlan)# band-select
Device(config)# end
```

## Examples: 802.11 Bands Configuration

This example shows how to configure 802.11 bands using beacon interval, fragmentation, and dynamic transmit power control:

```
Device# configure terminal
Device(config)# ap dot11 5ghz shutdown
Device(config)# ap dot11 24ghz shutdown
Device(config)# ap dot11 5ghz beaconperiod 500
Device(config)# ap dot11 5ghz fragmentation 300
Device(config)# ap dot11 5ghz dtpc
Device(config)# wireless client association limit 50 interval 1000
Device(config)# ap dot11 5ghz rate 36 mandatory
Device(config)# no ap dot11 5ghz shutdown
Device(config)# no ap dot11 24ghz shutdown
Device(config)# ap dot11 24ghz dot11g
Device(config)#end
```

## Examples: 802.11n Configuration

This example shows how to configure 802.11n parameters for 5-GHz band using aggregation method:

```
Device# configure terminal
Device(config)# ap dot11 5ghz dot11n
Device(config)# ap dot11 5ghz dot11n mcs tx 20
Device(config)# wlan wlan1 25 ssid12
Device(config-wlan)# wmm require\
Device(config-wlan)# exit
Device(config)# ap dot11 5ghz shutdown
Device(config)# ap dot11 5ghz dot11n a-mpdu tx priority all
Device(config)# no ap dot11 5ghz shutdown
Device(config)#exit
```

This example shows how to configure the guard interval for 5-GHz band:

```

Device# configure terminal
Device(config)# ap dot11 5ghz dot11n
Device(config)# ap dot11 5ghz dot11n mcs tx 20
Device(config)# wlan wlan1 25 ssid12
Device(config-wlan)# wmm require\
Device(config-wlan)# exit
Device(config)# no ap dot11 5ghz shutdown
Device(config)# ap dot11 5ghz dot11n guard-interval long
Device(config)#end

```

This example shows how to configure the RIFS for 5-GHz band:

```

Device# configure terminal
Device(config)# ap dot11 5ghz dot11n
Device(config)# ap dot11 5ghz dot11n mcs tx 20
Device(config)# wlan wlan1 25 ssid12
Device(config-wlan)# wmm require\
Device(config-wlan)# exit
Device(config)# ap dot11 5ghz shutdown
Device(config)# ap dot11 5ghz dot11n rifs rx
Device(config)#end

```

## Examples: 802.11h Configuration

This example shows how to configure the access point to announce when it is switching to a new channel using restriction transmission:

```

Device# configure terminal
Device(config)# ap dot11 5ghz shutdown
Device(config)# ap dot11 5ghz channelswitch mode 0
Device(config)# no ap dot11 5ghz shutdown
Device(config)#end

```

This example shows how to configure the 802.11h power constraint for 5-GHz band:

```

Device# configure terminal
Device(config)# ap dot11 5ghz shutdown
Device(config)# ap dot11 5ghz power-constraint 200
Device(config)# no ap dot11 5ghz shutdown
Device(config)#end

```

## Additional References for 802.11 Parameters and Band Selection

### Related Documents

| Related Topic              | Document Title                                                                               |
|----------------------------|----------------------------------------------------------------------------------------------|
| System management commands | <i>System Management Command Reference, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i> |



**Standards and RFCs**

| Standard/RFC | Title |
|--------------|-------|
| None         | —     |

**MIBs**

| MIB                                      | MIBs Link                                                                                                                                                                                                              |
|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| All the supported MIBs for this release. | To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:<br><a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a> |

**Technical Assistance**

| Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Link                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p> | <a href="http://www.cisco.com/support">http://www.cisco.com/support</a> |

## Feature History and Information For Performing 802.11 parameters and Band Selection Configuration

| Release            | Feature Information          |
|--------------------|------------------------------|
| Cisco IOS XE 3.2SE | This feature was introduced. |





## CHAPTER 134

# Configuring Aggressive Load Balancing

- [Finding Feature Information, on page 2485](#)
- [Restrictions for Aggressive Load Balancing, on page 2485](#)
- [Information for Configuring Aggressive Load Balancing Parameters, on page 2486](#)
- [How to Configure Aggressive Load Balancing, on page 2487](#)
- [Monitoring Aggressive Load Balancing, on page 2488](#)
- [Additional References for Aggressive Load Balancing, on page 2489](#)
- [Feature History and Information For Performing Aggressive Load Balancing Configuration , on page 2489](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Restrictions for Aggressive Load Balancing

- You can configure aggressive load balancing only from the command-line interface.
- Aggressive load balancing is disabled by default, you must enable it manually.
- You can enable load balancing either separately or together with the band select configurations.
- When the band select is enabled on the dual-band clients, the load balancing parameter selects only the lowest load radio from 5-GHz radios. For the 2.4-GHz clients, there is no probe information of the client on 5 GHz and therefore the load balancing algorithm can only be selected between radio on 2.4 GHz.
- You can operate load balancing of clients between access points on the same device but not for the clients between access points on the different device.
- The load balancing uses an existing association denial mechanism based on the number of client on the radio and the band select is implemented by the distributed probe response suppression on the access point only.

# Information for Configuring Aggressive Load Balancing Parameters

## Aggressive Load Balancing

Enabling aggressive load balancing on the controller allows lightweight access points to load balance wireless clients across access points. You can enable aggressive load balancing using the controller.

When a wireless client attempts to associate to a lightweight access point, association response packets are sent to the client with an 802.11 response packet including status code 17. The code 17 indicates that the AP is busy. The AP does not respond with an association response bearing 'success' if the AP threshold is not met, and with code 17 (AP busy) if the AP utilization threshold is exceeded, and another less busy AP heard the client request.

For example, if the number of clients on AP1 is more than the number of clients on AP2 plus the load-balancing window, then AP1 is considered to be busier than AP2. When a client attempts to associate to AP1, it receives an 802.11 response packet with status code 17, indicating that the access point is busy, and the client attempts to associate to a different access point.

You can configure the controller to deny client associations up to 10 times (if a client attempted to associate 11 times, it would be allowed to associate on the 11th try). You can also enable or disable load balancing on a particular WLAN, which is useful if you want to disable load balancing for a select group of clients (such as time-sensitive voice clients).

**Note**

Voice Client does not authenticate when delay is configured more than 300 ms. To avoid this configure a Central-Auth, Local Switching WLAN with CCKM, configure a Pagent Router between AP and WLC with a delay of 600 ms (300 ms UP and 300 ms DOWN and try associating the voice client

The maximum number of client associations that the access points can support is dependent upon the following factors:

- The maximum number of client associations differs for lightweight and autonomous Cisco IOS access points.
- There may be a limit per radio and an overall limit per AP.
- AP hardware (the 16-MB APs have a lower limit than the 32-MB and higher APs)

The Client Association Limits for Lightweight Access Points are as follows:

- For 16-MB APs, the limit is 128 clients per AP. This limit is applicable to 1100 and 1200 series APs.
- For 32-MB and higher APs, there is no per-AP limit.

The maximum Client Association Limits per-radio for all of the Cisco IOS APs is 200 associations.



---

**Note** With 32-MB and higher lightweight Cisco IOS APs, with two radios, up to  $200 + 200 = 400$  associations are supported.

---

The maximum Client Association Limits per Autonomous Cisco IOS access point is around 80 to 127 clients per AP. This number varies depending on the following factors:

- AP model (whether it is 16 MB or 32 MB or higher)
- Cisco IOS software release
- Hardware configuration (two radios use more memory than one)
- Enabled features (WDS functionality in particular)

The per-radio limit is about 200 associations. One association will likely hit the per-AP limit first. Unlike Cisco Unified Wireless Network, autonomous Cisco IOS supports per-SSID/per-AP association limits. This limit is configured using the `max-associations` CLI, under `dot11 SSID`. The maximum number is 255 associations (which is also the default number).



---

**Note** For a FlexConnect AP the association is locally handled. The load-balancing decisions are taken at the Cisco WLC. A FlexConnect AP initially responds to the client before knowing the result of calculations at the Cisco WLC. Load-balancing doesn't take effect when the FlexConnect AP is in standalone mode.

FlexConnect AP does not send (re)association response with status 17 for Load-Balancing as Local mode APs do; instead, it first sends (re)association with status 0 (success) and then death with reason 5.

---

# How to Configure Aggressive Load Balancing

## Configuring Aggressive Load Balancing (CLI)

### Procedure

---

**Step 1** Set the client window for aggressive load balancing by entering this command:

**wireless load-balancing window** *client\_count*

You can enter a value between 0 and 20 for the *client\_count* parameter.

**Step 2** Set the denial count for load balancing by entering this command:

**wireless load-balancing denial** *denial\_count*

You can enter a value between 1 and 10 for the *denial\_count* parameter.

**Step 3** Save your changes by entering this command:

**write memory**

**Step 4** Enter WLAN configuration mode by entering this command:

```
wlan profile-name wlan_ID SSID
```

You can enter a profile name with up to 32 alphanumeric characters for *profile-name* . You can enter a value between 1 and 512 for *wlan\_ID* parameter. You can enter a network name of up to 32 alphanumeric characters for *SSID* parameter.

**Step 5** Enable load balancing on the specific WLAN by entering this command:

```
load-balance
```

You can use **no load-balance** command to disable load balancing. .

**Step 6** Verify your settings by entering this command:

```
show wireless load-balancing
```

```
Aggressive Load Balancing.....: per WLAN enabling
Aggressive Load Balancing Window (clients).....: 5
Aggressive Load Balancing Denial Count.....: 3

Statistics
Total Denied Count (clients).....: 0
Total Denial Sent (messages).....: 0
Exceeded Denial Max Limit Count (times).....: 0
None 5G Candidate Count (times).....: 0
None 2.4G Candidate Count (times).....: 0
```

**Step 7** Save your changes by entering this command:

```
write memory
```

## Monitoring Aggressive Load Balancing

This section describes the new command for aggressive load balancing.

The following command can be used to monitor aggressive load balancing on the .

**Table 193: Monitoring Aggressive Load Balancing Command**

| Command                             | Purpose                                            |
|-------------------------------------|----------------------------------------------------|
| <b>show wireless load-balancing</b> | Displays the status of the load-balancing feature. |

## Additional References for Aggressive Load Balancing

### Related Documents

| Related Topic              | Document Title                                                                                     |
|----------------------------|----------------------------------------------------------------------------------------------------|
| System management commands | <i>System Management Command Reference Guide, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i> |

### Standards and RFCs

| Standard/RFC | Title |
|--------------|-------|
| None         | —     |

### MIBs

| MIB                                      | MIBs Link                                                                                                                                                                                                              |
|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| All the supported MIBs for this release. | To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:<br><a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a> |

### Technical Assistance

| Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Link                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p> | <a href="http://www.cisco.com/support">http://www.cisco.com/support</a> |

## Feature History and Information For Performing Aggressive Load Balancing Configuration

| Release            | Feature Information          |
|--------------------|------------------------------|
| Cisco IOS XE 3.2SE | This feature was introduced. |







## CHAPTER 135

# Configuring Client Roaming

- [Finding Feature Information, on page 2491](#)
- [Restrictions for Configuring Client Roaming, on page 2491](#)
- [Information About Client Roaming, on page 2491](#)
- [How to Configure Layer 2 or Layer 3 Roaming, on page 2494](#)
- [Monitoring Client Roaming Parameters, on page 2500](#)
- [Monitoring Mobility Configurations, on page 2500](#)
- [Additional References for Configuring Client Roaming, on page 2501](#)
- [Feature History and Information For Performing Client Roaming Configuration , on page 2502](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Restrictions for Configuring Client Roaming

The following are the restrictions that you should be aware while configuring client roaming:

- Cisco Compatible Extensions (CCX) support is enabled automatically for every WLAN on the device and cannot be disabled. The device stores the CCX version of the client in its client database and uses it to generate and respond to CCX frames appropriately. Clients must support CCXv4 or v5 (or CCXv2 for access point assisted roaming) to utilize these roaming enhancements.
- Client roaming between 600 Series Access points is not supported.

## Information About Client Roaming

The controllers deliver high-end wireless services to the clients roaming across wireless network. Now, the wireless services are integrated with the switches, thus delivering a value-added Cisco unified new mobility

architecture. This unified architecture enables client-roaming services to both wireless and wired clients with seamless, fast- roaming services.

The new mobility architecture supports fast client roaming services using logical categorization of network into Mobility Domains (MDs), Mobility Groups (MGs), Mobility Subdomains (MSDs), and Switch Peer Groups (SPGs) using systems such as Mobility Oracle (MO), Mobility Controller (MC), and Mobility Agent (MA).

- A **Mobility Domain** is the entire domain across which client roaming is supported. It is a collection of mobility groups. For example, a campus network can be considered as a mobility domain.
- A **Mobility Group** is a collection of mobility subdomains across which fast roaming is supported. The mobility group can be one or more buildings within a campus across which frequent roaming is supported.
- A **Mobility Subdomain** is an autonomous portion of the mobility domain network. Each mobility subdomain contains one mobility controller (MC) and a collection of SPGs. A subdomain is equivalent to an 802.11r key domain.
- A **Switch Peer Group** is a collection of mobility agents.
- The **Mobility Oracle** acts as the point of contact for mobility events that occur across mobility subdomains. The mobility oracle also maintains a local database of each client in the entire mobility domain, their home and current subdomain. There is only one MO for an entire mobility domain. The Cisco WLC 5700 Series Controllers or Cisco Unified Wireless Networking Solution controller can act as MO.
- The **Mobility Controller** provides mobility management services for inter-SPG roaming events. The MC sends the configuration like SPG name and SPG peer member list to all of the mobility agents under its subdomain. The Cisco WLC 5700 Series Controllers, Cisco Catalyst 3850 Switch, or Cisco Unified Wireless Networking Solution controller can act as MC. The MC has MC functionality and MA functionality that is running internally into it.
- The **Mobility Agent** is the component that maintains client mobility state machine for a mobile client. All APs are connected to the mobility agent.

The New mobility architecture supports seamless roaming in the following scenarios:

- Intra-switch roaming—The client roaming between APs managed by same mobility agent.
- Intra-SPG roaming—The client roaming between mobility agents in the same SPG.
- Inter-SPG, Intra-subdomain roaming—The client roaming between mobility agents in different SPGs within the same subdomain.
- Inter-subdomain roaming—The client roaming between mobility agents across a subdomain.

### Fast Roaming

New mobility architecture supports fast roaming when clients roam within a mobility group by eliminating the need for full authentication. Security polices should be same across the switches for fast roaming.

### Local, anchor, foreign MAs and MCs

When a client joins an MA initially and its point of attachment has not changed, that MA is referred as local or associated MA. The MC to which this MA is associated is referred as local or associated MC.

When a client roams between two MAs, the MA to which the client was previously associated is the anchor MA (point of attachment) and the MA to which the client is currently associated is the foreign or associated

MA (point of presence). The MCs to which these MAs are associated are referred as anchor, foreign, or associated MCs, respectively.

## Inter-Subnet Roaming

Multiple-controller deployments support client roaming across access points managed by controllers in the same mobility group on different subnets. This roaming is transparent to the client because the session is sustained and a tunnel between the controllers allows the client to continue using the same DHCP-assigned or client-assigned IP address as long as the session remains active. The tunnel is torn down, and the client must reauthenticate when the client sends a DHCP Discover with a 0.0.0.0 client IP address or a 169.254.\*.\* client auto-IP address or when the operator-set user timeout is exceeded.

## Voice-over-IP Telephone Roaming

802.11 voice-over-IP (VoIP) telephones actively seek out associations with the strongest RF signal to ensure the best quality of service (QoS) and the maximum throughput. The minimum VoIP telephone requirement of 20-millisecond or shorter latency time for the roaming handover is easily met by the Cisco Wireless solution, which has an average handover latency of 5 or fewer milliseconds when open authentication is used. This short latency period is controlled by controllers rather than allowing independent access points to negotiate roaming handovers.

The Cisco Wireless solution supports 802.11 VoIP telephone roaming across lightweight access points managed by controllers on different subnets, as long as the controllers are in the same mobility group. This roaming is transparent to the VoIP telephone because the session is sustained and a tunnel between controllers allows the VoIP telephone to continue using the same DHCP-assigned IP address as long as the session remains active. The tunnel is torn down, and the VoIP client must reauthenticate when the VoIP telephone sends a DHCP Discover with a 0.0.0.0 VoIP telephone IP address or a 169.254.\*.\* VoIP telephone auto-IP address or when the operator-set user timeout is exceeded.

## CCX Layer 2 Client Roaming

The controller supports five CCX Layer 2 client roaming enhancements:

- Access point assisted roaming—This feature helps clients save scanning time. When a CCXv2 client associates to an access point, it sends an information packet to the new access point listing the characteristics of its previous access point. Roaming time decreases when the client recognizes and uses an access point list built by compiling all previous access points to which each client was associated and sent (unicast) to the client immediately after association. The access point list contains the channels, BSSIDs of neighbor access points that support the client's current SSID(s), and time elapsed since disassociation.
- Enhanced neighbor list—This feature focuses on improving a CCXv4 client's roam experience and network edge performance, especially when servicing voice applications. The access point provides its associated client information about its neighbors using a neighbor-list update unicast message.
- Enhanced neighbor list request (E2E)—The End-2-End specification is a Cisco and Intel joint program that defines new protocols and interfaces to improve the overall voice and roaming experience. It applies only to Intel clients in a CCX environment. Specifically, it enables Intel clients to request a neighbor list at will. When this occurs, the access point forwards the request to the controller. The controller receives the request and replies with the current CCX roaming sublist of neighbors for the access point to which the client is associated.



**Note** To see whether a particular client supports E2E, choose **Wireless > Clients** on the controller GUI, click the **Detail** link for the desired client, and look at the E2E Version text box in the Client Properties area.

- Roam reason report—This feature enables CCXv4 clients to report the reason why they roamed to a new access point. It also allows network administrators to build and monitor a roam history.
- Directed roam request—This feature enables the controller to send directed roam requests to the client in situations when the controller can better service the client on an access point different from the one to which it is associated. In this case, the controller sends the client a list of the best access points that it can join. The client can either honor or ignore the directed roam request. Non-CCX clients and clients running CCXv3 or below must not take any action. No configuration is required for this feature.

## How to Configure Layer 2 or Layer 3 Roaming

### Configuring Layer 2 or Layer 3 Roaming

#### Before you begin

To configure the mobility agent for Layer 2 or Layer 3 roaming, the following requisites should be considered:

- SSID and security polices should be same across MAs for Layer 2 and Layer 3 roaming.
- Client VLAN ID should be same for Layer 2 roaming and different for Layer 3 roaming.
- Bridge domain ID and client VLAN IDs should be same for Layer 2 roaming. Either one or both of the bridge domain ID and client VLAN ID should be different for Layer 3 roaming.

#### Procedure

|               | Command or Action                                                                                                              | Purpose                                |
|---------------|--------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                              | Enters global configuration mode.      |
| <b>Step 2</b> | <b>wlan wlan_profile_name wlan_ID<br/>           SSID_network_name</b><br><b>Example:</b><br>Device(config)# <b>wlan wlan1</b> | Enters WLAN configuration mode.        |
| <b>Step 3</b> | <b>no mobility anchor sticky</b><br><b>Example:</b><br>Device(config-wlan)# <b>no mobility anchor<br/>           sticky</b>    | (Optional) Disables Layer 2 anchoring. |

|               | Command or Action                                           | Purpose                                                                                                             |
|---------------|-------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| <b>Step 4</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b> | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

## Configuring CCX Client Roaming Parameters (CLI)

### Procedure

|               | Command or Action                                                                                                                                                                           | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                                                                           | Enters global configuration mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Step 2</b> | <b>ap dot11 {5ghz   24ghz} l2roam rf-params {default   custom min-rssi roam-hyst scan-thresh trans-time}</b><br><b>Example:</b><br>Device# <b>ap dot11 5ghz l2roam rf-params custom -80</b> | <p>Configures CCX Layer 2 client roaming parameters.</p> <p>To choose the default RF parameters, enter the <b>default</b> option.</p> <p>To fine-tune the RF parameters that affect client roaming, enter the <b>custom</b> option and then enter any one of the following options:</p> <ul style="list-style-type: none"> <li>• <b>Minimum RSSI</b>—Indicates minimum Received Signal Strength Indicator (RSSI) required for the client to associate to an access point.<br/><br/>If the client's average received signal power dips below this threshold, reliable communication is usually impossible. Therefore, clients must already have found and roamed to another access point with a stronger signal before the minimum RSSI value is reached.<br/><br/>You can configure the minimum RSSI range from <math>-50</math> through <math>-90</math> dBm and the default value is <math>-85</math> dBm.</li> <li>• <b>Hysteresis</b>—Indicates how much greater the signal strength of a neighboring access point must be for the client to roam to it.<br/><br/>This parameter is intended to reduce the amount of roaming between access points if the client is physically located on or near the border between two access points.</li> </ul> |

|               | Command or Action                                                       | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------|-------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               |                                                                         | <p>You can configure the hysteresis range from 3 through 20 dB and the default is 3 dB.</p> <ul style="list-style-type: none"> <li>• Scan Threshold—Indicates a minimum RSSI that is allowed before the client should roam to a better access point.</li> </ul> <p>When the RSSI drops below the specified value, the client must be able to roam to a better access point within the specified transition time. This parameter also provides a power-save method to minimize the time that the client spends in active or passive scanning. For example, the client can scan slowly when the RSSI is above the threshold and scan more rapidly when the RSSI is below the threshold.</p> <p>You can configure the RSSI range from –50 through –90 dBm and the default value is –72 dBm.</p> <ul style="list-style-type: none"> <li>• Transition Time—Indicates the maximum time allowed for the client to detect a suitable neighboring access point to roam to and to complete the roam, whenever the RSSI from the client’s associated access point is below the scan threshold.</li> </ul> <p>The Scan Threshold and Transition Time parameters guarantee a minimum level of client roaming performance. Together with the highest expected client speed and roaming hysteresis, these parameters make it possible to design a wireless LAN network that supports roaming simply by ensuring a certain minimum overlap distance between access points.</p> <p>You can configure the time period in the range from 1 through 5 seconds and the default time is 5 seconds.</p> |
| <b>Step 3</b> | <p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre> | <p>Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

## Example

## Configuring Mobility Oracle

## Procedure

|               | Command or Action                                                                                           | Purpose                                                                                                             |
|---------------|-------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <code>configure terminal</code>                     | Enters global configuration mode.                                                                                   |
| <b>Step 2</b> | <b>wireless mobility oracle</b><br><b>Example:</b><br>Device(config)# <code>wireless mobility oracle</code> | Enables mobility oracle on the controller.                                                                          |
| <b>Step 3</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <code>end</code>                                           | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

## Example

## Configuring Mobility Controller

## Procedure

|               | Command or Action                                                                                                                                                               | Purpose                                                                                                                                                                                                                                                 |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <code>configure terminal</code>                                                                                         | Enters global configuration mode.                                                                                                                                                                                                                       |
| <b>Step 2</b> | <b>wireless mobility controller</b><br><b>Example:</b><br>Device(config)# <code>wireless mobility controller</code>                                                             | Enables wireless mobility controller.                                                                                                                                                                                                                   |
| <b>Step 3</b> | <b>wireless mobility controller peer-group</b><br><i>switch-peer-group-name</i><br><b>Example:</b><br>Device(config)# <code>wireless mobility controller peer-group SPG1</code> | Configures a switch peer group name. You can enter up to 31 case-sensitive ASCII printable characters for the group name. Spaces are not allowed in mobility group.<br><br><b>Note</b> The <b>No</b> form of the command deletes the switch peer group. |

|         | Command or Action                                                                                                                                                                                                                                                         | Purpose                                                                                                                                                                               |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Step 4  | <p><b>wireless mobility controller peer-group</b><br/> <i>switch-peer-group-name member ip</i><br/> <i>ip-address {public-ip public-ip-address}</i></p> <p><b>Example:</b></p> <pre>Device(config)# wireless mobility controller peer-group SPG1 member ip 10.0.0.1</pre> | <p>Adds a mobility group member to a switch peer group.</p> <p><b>Note</b> The <b>No</b> form of the command deletes the member from the switch peer group.</p>                       |
| Step 5  | <p><b>wireless mobility controller peer-group</b><br/> <i>switch-peer-group-name multicast</i></p> <p><b>Example:</b></p> <pre>Device(config)# wireless mobility controller peer-group SPG1 multicast</pre>                                                               | <p>Configures the multicast mode within a switch peer group.</p>                                                                                                                      |
| Step 6  | <p><b>wireless mobility controller peer-group</b><br/> <i>switch-peer-group-name multicast ip</i><br/> <i>peer-group-multicast-ip-addr</i></p> <p><b>Example:</b></p> <pre>Device(config)# wireless mobility controller peer-group SPG1 multicast ip 10.0.0.4</pre>       | <p>Configures the multicast IP address for a switch peer group.</p> <p><b>Note</b> The <b>No</b> form of the command deletes the multicast IP for the switch peer group.</p>          |
| Step 7  | <p><b>wireless mobility controller</b><br/> <b>peer-group</b><i>switch-peer-group-name</i><br/> <b>bridge-domain-id</b> <i>id</i></p> <p><b>Example:</b></p> <pre>Device(config)# wireless mobility controller peer-group SPG bridge-domain-id 10.0.0.5</pre>             | <p>Configures the bridge domain ID for a switch peer group. The default is zero.</p> <p><b>Note</b> The <b>No</b> form of command sets the bridge domain ID to the default value.</p> |
| Step 8  | <p><b>wireless mobility group member ip</b><br/> <i>ip-address [public-ip public-ip-address]</i><br/> <i>[group group-name]</i></p> <p><b>Example:</b></p> <pre>Device(config)# wireless mobility group member ip 10.0.0.1</pre>                                          | <p>Adds a mobility group member.</p> <p><b>Note</b> The <b>No</b> form of the command removes the member from the group. The default group name is the group name of MC.</p>          |
| Step 9  | <p><b>wireless mobility dscp</b> <i>value</i></p> <p><b>Example:</b></p> <pre>Device(config)# wireless mobility dscp 46</pre>                                                                                                                                             | <p>Sets the DSCP value for mobility control packet.</p> <p>You can configure the DSCP value in a range from 0 through 63. The default value is 46.</p>                                |
| Step 10 | <p><b>wireless mobility group keepalive</b> <i>{count   interval}</i></p>                                                                                                                                                                                                 | <p>Configures the wireless mobility group keepalive count which is the number of keepalive retries before a member status is</p>                                                      |



|                | Command or Action                                                                                                                           | Purpose                                                                                                             |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
|                | <b>Example:</b><br>Device(config)# wireless mobility group<br>keepalive count                                                               | termed DOWN and keepalive interval which is interval between two keepalives.                                        |
| <b>Step 11</b> | <b>wireless mobility group name</b> <i>name</i><br><b>Example:</b><br>Device(config)# wireless mobility group<br>name group1                | Specifies the case sensitive wireless mobility group name which can be ASCII printable string up to 31 characters.  |
| <b>Step 12</b> | <b>wireless mobility oracle ip</b> <i>mo-ip-address</i><br><b>Example:</b><br>Device(config)# wireless mobility oracle<br>ip 10.0.0.5       | Configures the mobility oracle IP address.                                                                          |
| <b>Step 13</b> | <b>wireless management interface</b><br><i>interface-name</i><br><b>Example:</b><br>Device(config)# wireless management<br>interface Vlan21 | Configures the wireless management interface.                                                                       |
| <b>Step 14</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b>                                                                                 | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

### Example

## Configuring Mobility Agent

### Procedure

|               | Command or Action                                                                                                                             | Purpose                                         |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                             | Enters global configuration mode.               |
| <b>Step 2</b> | <b>wireless mobility controller ip</b> <i>ip-address</i><br><b>Example:</b><br>Device(config)# wireless mobility<br>controller ip 10.10.10.20 | Sets the IP address of the mobility controller. |
| <b>Step 3</b> | <b>wireless mobility load-balance</b><br><b>Example:</b><br>Device(config)# wireless mobility<br>load-balance                                 | Configures wireless mobility load balancing.    |

|               | Command or Action                                                                                                                                                            | Purpose                                                                                                                                                                 |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 4</b> | <b>wireless mobility load-balance threshold</b><br><i>threshold -value</i><br><br><b>Example:</b><br><pre>Device(config)# wireless mobility load-balance threshold 100</pre> | Configures the number of clients that can be local or anchored on the MA. You can configure the threshold value in a range from 100 to 2000. The default value is 1000. |
| <b>Step 5</b> | <b>wireless management interface</b> <i>interface-name</i><br><br><b>Example:</b><br><pre>Device(config)# wireless management interface Vlan21</pre>                         | Configures wireless management interface for the mobility agent.                                                                                                        |
| <b>Step 6</b> | <b>end</b><br><br><b>Example:</b><br><pre>Device(config)# end</pre>                                                                                                          | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                     |

## Monitoring Client Roaming Parameters

This section describes the new commands for the client parameters.

The following commands can be used to monitor the client roaming parameters on the .

**Table 194: Monitoring Client Roaming Parameters Commands**

| Command                                                                              | Purpose                                                                                                |
|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| <b>show ap dot11 {5ghz   24ghz} l2roam rf-param</b>                                  | Displays the current RF parameters configured for client roaming for the 802.11a or 802.11b/g network. |
| <b>show ap dot11 {5ghz   24ghz} l2roam statistics</b>                                | Displays the CCX Layer 2 client roaming statistics for the 802.11a or 802.11b/g network.               |
| <b>show ap dot11 {5ghz   24ghz} l2roam mac-address <i>mac-address</i> statistics</b> | Displays the CCX Layer 2 client roaming statistics for a particular access point.                      |

## Monitoring Mobility Configurations

This section describes the new commands for monitoring mobility configurations.

The following command can be used to monitor mobility configurations on the Mobility Oracle, Mobility Controller, and Mobility Agent.

**Table 195: Monitoring Mobility Configuration Commands on the Mobility Controller and Mobility Agent**

| Command                               | Purpose                                                                          |
|---------------------------------------|----------------------------------------------------------------------------------|
| <b>show wireless mobility summary</b> | Displays the summary information for the Mobility Controller and Mobility Agent. |

|                                                |                                        |
|------------------------------------------------|----------------------------------------|
| <b>show wireless mobility statistics</b>       | Displays mobility statistics.          |
| <b>show wireless mobility dtls connections</b> | Displays established DTLS connections. |

**Table 196: Monitoring Mobility Configuration Commands on the Mobility Oracle**

| Command                                                                          | Purpose                                                                                                                                           |
|----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>show wireless mobility oracle summary</b>                                     | Displays the status of the Mobility Controllers known to the Mobility Oracle.                                                                     |
| <b>show wireless mobility oracle client summary</b>                              | Displays the information of a list of clients in the Mobility Oracle database.                                                                    |
| <b>show wireless mobility oracle client detail</b><br><i>client -mac-address</i> | Displays the detailed information of a particular client in the Mobility Oracle database.                                                         |
| <b>show wireless mobility oracle mc-ip</b>                                       | Displays the information of a list of clients in the Mobility Oracle database that are anchored or associated to a specified Mobility Controller. |

**Table 197: Monitoring Mobility Configuration Commands on the Mobility Controller**

| Command                                                                      | Purpose                                                                          |
|------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| <b>show wireless mobility controller client summary</b>                      | Displays a list of clients in the subdomain.                                     |
| <b>show wireless mobility controller client</b><br><i>mac-address detail</i> | Displays detailed information for a client in a subdomain.                       |
| <b>show wireless mobility agent ma-ip client</b><br><b>summary</b>           | Displays a list of clients anchored or associated to a specified Mobility Agent. |
| <b>show wireless mobility ap-list</b>                                        | Displays the list of Cisco APs known to the mobility group.                      |

**Table 198: Monitoring Mobility Configuration Commands on the Mobility Agent**

| Command                                            | Purpose                                                   |
|----------------------------------------------------|-----------------------------------------------------------|
| <b>show wireless mobility load-balance summary</b> | Displays the summary of mobility load-balance properties. |

## Additional References for Configuring Client Roaming

### Related Documents

| Related Topic          | Document Title                                                                        |
|------------------------|---------------------------------------------------------------------------------------|
| Mobility configuration | <i>Mobility Configuration Guide, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i> |

| Related Topic             | Document Title                                                                            |
|---------------------------|-------------------------------------------------------------------------------------------|
| Mobility-related commands | <i>Mobility Command Reference Guide, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i> |

### Standards and RFCs

| Standard/RFC | Title |
|--------------|-------|
| None         | —     |

### MIBs

| MIB                                      | MIBs Link                                                                                                                                                                                                                  |
|------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| All the supported MIBs for this release. | To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:<br><br><a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a> |

### Technical Assistance

| Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Link                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p> | <a href="http://www.cisco.com/support">http://www.cisco.com/support</a> |

## Feature History and Information For Performing Client Roaming Configuration

| Release            | Feature Information          |
|--------------------|------------------------------|
| Cisco IOS XE 3.2SE | This feature was introduced. |



## CHAPTER 136

# Configuring Application Visibility and Control in a Wired Network

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Application Visibility and Control (AVC) is a solution for Cisco network devices that provides application-level classification, monitoring, and traffic control to improve business-critical application performance, facilitate capacity management and planning, and reduce network operating costs. The Cisco AVC solution is provided within the Branch and Aggregation routers, Cisco Switches, and Cisco Wireless Controllers and Access points.

For information about AVC on Cisco Switches, see *Configuring Application Visibility and Control in a Wired Network*.

For information about AVC on Cisco Wireless Controllers and Access points, see *Configuring Application Visibility and Control*.

- [Information About Application Visibility and Control in a Wired Network, on page 2503](#)
- [Supported AVC Class Map and Policy Map Formats, on page 2504](#)
- [Restrictions for Application Visibility and Control, on page 2505](#)
- [How to Configure Application Visibility and Control, on page 2506](#)
- [Monitoring Application Visibility and Control, on page 2521](#)
- [Examples: Application Visibility and Control, on page 2521](#)
- [Basic Troubleshooting\(Questions and Answers\), on page 2531](#)
- [Additional References for Application Visibility and Control, on page 2532](#)
- [Feature History and Information For Application Visibility and Control in a Wired Network, on page 2532](#)

## Information About Application Visibility and Control in a Wired Network

Application Visibility and Control (AVC) is a critical part of Cisco's efforts to evolve its Branch and Campus solutions from being strictly packet and connection based to being application-aware and application-intelligent. Application Visibility and Control (AVC) classifies applications using deep packet inspection techniques with the Network-Based Application Recognition (NBAR2) engine. AVC can be configured on wired access ports for standalone switches as well as for a switch stack. NBAR2 can be activated either explicitly on the interface by enabling protocol-discovery or implicitly by attaching a QoS policy that contains **match protocol** classifier. Wired AVC Flexible NetFlow (FNF) can be configured on an interface to provide client, server and application statistics per interface. The record is similar to **application-client-server-stats** traffic monitor which is

available in **application-statistics** and **application-performance** profiles in Easy Performance Monitor (Easy perf-mon or ezPM).

## Supported AVC Class Map and Policy Map Formats

### Supported AVC Class Map Format

| Class Map Format                                 | Class Map Example                                                                              | Direction               |
|--------------------------------------------------|------------------------------------------------------------------------------------------------|-------------------------|
| <code>match protocol <i>protocol name</i></code> | <code>class-map match-any NBAR-VOICE<br/>match protocol ms-lync-audio</code>                   | Both ingress and egress |
| Combination filters                              | <code>class-map match-any NBAR-VOICE<br/>match protocol ms-lync-audio<br/>match dscp ef</code> | Both ingress and egress |

### Supported AVC Policy Format

| Policy Format                                 | QoS Action      |
|-----------------------------------------------|-----------------|
| Egress policy based on match protocol filter  | Mark and police |
| Ingress policy based on match protocol filter | Mark and police |

The following table describes the detailed AVC policy format with an example:

| AVC Policy Format                         | AVC Policy Example                                                                                                                                                                                                      | Direction          |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| Basic set                                 | <code>policy-map MARKING-IN<br/>class NBAR-MM_CONFERENCING<br/>set dscp af41</code>                                                                                                                                     | Ingress and egress |
| Basic police                              | <code>policy-map POLICING-IN<br/>class NBAR-MM_CONFERENCING<br/>police cir 600000<br/>set dscp af41</code>                                                                                                              | Ingress and egress |
| Basic set and police                      | <code>policy-map webex-policy<br/>class webex-class<br/>set dscp ef<br/>cos police 5000000</code>                                                                                                                       | Ingress and egress |
| Multiple set and police including default | <code>policy-map webex-policy<br/>class webex-class<br/>set dscp af31<br/>cos police 4000000<br/>class class-webex-category<br/>set dscp ef<br/>cos police 6000000<br/>class class-default<br/>set dscp &lt;&gt;</code> | Ingress and egress |

| AVC Policy Format           | AVC Policy Example                                                                                                                                                                                                                                    | Direction          |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| Hierarchical police         | <pre> policy-map webex-policy   class webex-class   police 5000000   service-policy client-in-police-only  policy-map client-in-police-only   class webex-class   police 100000   class class-webex-category   set dscp ef   cos police 200000 </pre> | Ingress and egress |
| Hierarchical set and police | <pre> policy-map webex-policy   class class-default   police 1500000   service policy client-up-child   policy-map webex-policy   class webex-class   police 100000   set dscp ef   class class-webex-category   police 200000   set dscp af31 </pre> |                    |

## Restrictions for Application Visibility and Control

- NBAR based QoS policy configuration is allowed only on wired physical ports. Policy configuration is not supported on virtual interfaces, for example, VLAN, Port-Channel and other logical interfaces.
- NBAR2 based match criteria **match protocol** will be allowed only with marking or policing actions. NBAR2 match criteria will not be allowed in a policy that has queuing features configured.
- ‘Match Protocol’: up to 255 concurrent different protocols in all policies (8 bits HW limitation).
- NBAR2 attributes based QoS is not supported (**match protocol** attribute).
- AVC is not supported on management port (Gig 0/0).
- IPv6 packet classification is not supported.
- Only IPv4 unicast(TCP/UDP) is supported.
- NBAR and NetFlow cannot be configured together at the same time on the same interface.
- Web UI: You can configure application visibility and perform application monitoring from the Web UI. Application Control can only be done using the CLI. It is not supported on the Web UI.  
To manage and check wired AVC traffic on the Web UI, you must first configure **ip http authentication local** and **ip nbar http-service** commands using the CLI.
- NBAR and ACL logging cannot be configured together on the same switch.
- Protocol-discovery, application-based QoS, and wired AVC FNF cannot be configured together at the same time on the same interface with the non-application-based FNF. However, these wired AVC features

can be configured with each other. For example, protocol-discovery, application-based QoS and wired AVC FNF can be configured together on the same interface at the same time.

- A single predefined record is supported with wired AVC FNF.
- Attachment should be done only on physical Layer2 (Access/Trunk) and Layer3 ports. Uplink can be attached as long as it is a single uplink and is not part of a port channel.
- Performance: Each switch member is able to handle 500 connections per second (CPS) at less than 50% CPU utilization.
- Scale: Able to handle up to 10,000 bi-directional flows per 48 access ports and 5000 bi-directional flows per 24 access ports. (~200 flows per access port).
- Wired AVC allows only the fixed set of fields listed in the procedures of this chapter. Other combinations are not allowed. For a regular FNF flow monitor, other combinations are allowed (for the list of supported FNF fields, refer the "Configuring Flexible NetFlow" chapter of the *Network Management Configuration Guide*).

# How to Configure Application Visibility and Control

## Configuring Application Visibility and Control in a Wired Network

To configure application visibility and control on wired ports, follow these steps:

### Configuring Visibility :

- Activate NBAR2 engine by enabling protocol-discovery on the interface using the **ip nbar protocol-discovery** command in the interface configuration mode. See the *Enabling Application Recognition on an Interface* section.

**Configuring Control :** Configure QoS policies based on application by

1. Creating an AVC QoS policy.
2. Applying AVC QoS policy to the interface.

### Configuring application-based Flexible Netflow :

- Create a flow record by specifying key and non-key fields to the flow.
- Create a flow exporter to export the flow record.
- Create a flow monitor based on the flow record and the flow exporter.
- Attach the flow monitor to the interface.

Protocol-Discovery, application-based QoS and application-based FNF are all independent features. They can be configured independently or together on the same interface at the same time.

## Enabling Application Recognition on an interface

To enable application recognition on an interface, follow these steps:



**Procedure**

|               | <b>Command or Action</b>                                                                                                    | <b>Purpose</b>                                                                                                 |
|---------------|-----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br><br>Device# <code>configure terminal</code>                                 | Enters global configuration mode.                                                                              |
| <b>Step 2</b> | <b>interface <i>interface-id</i></b><br><b>Example:</b><br><br>Device(config)# <code>interface gigabitethernet 1/0/1</code> | Specifies the interface for which you are enabling protocol-discovery and enters interface configuration mode. |
| <b>Step 3</b> | <b>ip nbar protocol-discovery</b><br><b>Example:</b><br><br>Device(config-if)# <code>ip nbar protocol-discovery</code>      | Enables application recognition on the interface by activating NBAR2 engine.                                   |
| <b>Step 4</b> | <b>end</b><br><b>Example:</b><br><br>Device(config-if)# <code>end</code>                                                    | Returns to privileged EXEC mode.                                                                               |

**Creating AVC QoS Policy**

To create AVC QoS policy, perform these general steps:

1. Create a class map with match protocol filters.
2. Create a policy map.
3. Apply the policy map to the interface.

**Creating a Class Map**

You need to create a class map before configuring any match protocol filter. The QoS actions such as marking and policing can be applied to the traffic. The AVC match protocol filters are applied to the wired access ports. For more information about the protocols that are supported, see [http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/qos\\_nbar/prot\\_lib/config\\_library/nbar-prot-pack-library.html](http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/qos_nbar/prot_lib/config_library/nbar-prot-pack-library.html).

**Procedure**

|               | <b>Command or Action</b>                     | <b>Purpose</b>                    |
|---------------|----------------------------------------------|-----------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b> | Enters global configuration mode. |

|               | Command or Action                                                                                                                                                                            | Purpose                                                                                                                |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
|               | Device# <code>configure terminal</code>                                                                                                                                                      |                                                                                                                        |
| <b>Step 2</b> | <code>class-map</code> <i>class-map-name</i><br><b>Example:</b><br>Device(config)# <code>class-map webex-class</code>                                                                        | Creates a class map.                                                                                                   |
| <b>Step 3</b> | <code>match protocol</code> <i>application-name</i><br><b>Example:</b><br>Device(config)# <code>class-map webex-class</code><br>Device(config-cmap)# <code>match protocol webex-media</code> | Specifies match to the application name.                                                                               |
| <b>Step 4</b> | <code>end</code><br><b>Example:</b><br>Device(config)# <code>end</code>                                                                                                                      | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

## Creating a Policy Map

### Procedure

|               | Command or Action                                                                                                                             | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <code>configure terminal</code><br><b>Example:</b><br>Device# <code>configure terminal</code>                                                 | Enters global configuration mode.                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Step 2</b> | <code>policy-map</code> <i>policy-map-name</i><br><b>Example:</b><br>Device(config)# <code>policy-map webex-policy</code>                     | Creates a policy map by entering the policy map name, and enters policy-map configuration mode.<br><br>By default, no policy maps are defined.<br><br>The default behavior of a policy map is to set the DSCP to 0 if the packet is an IP packet and to set the CoS to 0 if the packet is tagged. No policing is performed.<br><br><b>Note</b> To delete an existing policy map, use the <b>no policy-map</b> <i>policy-map-name</i> global configuration command. |
| <b>Step 3</b> | <code>class</code> [ <i>class-map-name</i>   <b>class-default</b> ]<br><b>Example:</b><br>Device(config-pmap)# <code>class webex-class</code> | Defines a traffic classification, and enters policy-map class configuration mode.<br><br>By default, no policy map and class maps are defined.<br><br>If a traffic class has already been defined by using the <b>class-map</b> global configuration                                                                                                                                                                                                               |

|               | Command or Action                                                                                                                                    | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               |                                                                                                                                                      | <p>command, specify its name for <i>class-map-name</i> in this command.</p> <p>A <b>class-default</b> traffic class is predefined and can be added to any policy. It is always placed at the end of a policy map. With an implied <b>match any</b> is included in the <b>class-default</b> class, all packets that have not already matched the other traffic classes will match <b>class-default</b>.</p> <p><b>Note</b> To delete an existing class map, use the <b>no class</b> <i>class-map-name</i> policy-map configuration command.</p> |
| <b>Step 4</b> | <p><b>police</b> <i>rate-bps burst-byte</i></p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# police 100000 80000</pre>                         | <p>Defines a policer for the classified traffic.</p> <p>By default, no policer is defined.</p> <ul style="list-style-type: none"> <li>For <i>rate-bps</i>, specify an average traffic rate in bits per second (b/s). The range is 8000 to 10000000000.</li> <li>For <i>burst-byte</i>, specify the normal burst size in bytes. The range is 8000 to 1000000.</li> </ul>                                                                                                                                                                        |
| <b>Step 5</b> | <p><b>set</b> { <b>dscp</b> <i>new-dscp</i>   <b>cos</b> <i>cos-value</i> }</p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# set dscp 45</pre> | <p>Classifies IP traffic by setting a new value in the packet.</p> <ul style="list-style-type: none"> <li>For <b>dscp</b> <i>new-dscp</i>, enter a new DSCP value to be assigned to the classified traffic. The range is 0 to 63.</li> </ul>                                                                                                                                                                                                                                                                                                   |
| <b>Step 6</b> | <p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>                                                                              | <p>Returns to privileged EXEC mode.</p> <p>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.</p>                                                                                                                                                                                                                                                                                                                                                                                                              |

## Applying a QoS Policy to the switch port

### Procedure

|               | Command or Action                                                                             | Purpose                                  |
|---------------|-----------------------------------------------------------------------------------------------|------------------------------------------|
| <b>Step 1</b> | <p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre> | Enters global configuration mode.        |
| <b>Step 2</b> | <p><b>interface</b> <i>interface-id</i></p> <p><b>Example:</b></p>                            | Enters the interface configuration mode. |

|               | Command or Action                                                                                                                                | Purpose                                                                                                                |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
|               | Device (config) # <b>interface</b> Gigabitethernet<br>1/0/1                                                                                      |                                                                                                                        |
| <b>Step 3</b> | <b>service-policy input</b> <i>polycymapname</i><br><br><b>Example:</b><br>Device (config-if) # <b>service-policy input</b><br><b>MARKING_IN</b> | Applies local policy to interface.                                                                                     |
| <b>Step 4</b> | <b>end</b><br><br><b>Example:</b><br>Device (config) # <b>end</b>                                                                                | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

## Configuring Wired AVC Flexible Netflow

### Creating a Flow Record

A single flow record can be configured and associated with a flow monitor.

#### Procedure

|               | Command or Action                                                                                                                 | Purpose                                                   |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><br><b>Example:</b><br>Device# <b>configure terminal</b>                                             | Enters global configuration mode.                         |
| <b>Step 2</b> | <b>flow record</b> <i>flow_record_name</i><br><br><b>Example:</b><br>Device (config) # <b>flow record</b><br>flow-record-1        | Enters flow record configuration mode.                    |
| <b>Step 3</b> | <b>description</b> <i>description</i><br><br><b>Example:</b><br>Device (config-flow-record) # <b>description</b><br>flow-record-1 | (Optional) Creates a description for the flow record.     |
| <b>Step 4</b> | <b>match ipv4 version</b><br><br><b>Example:</b><br>Device (config-flow-record) # <b>match ipv4</b><br><b>version</b>             | Specifies a match to the IP version from the IPv4 header. |
| <b>Step 5</b> | <b>match ipv4 protocol</b><br><br><b>Example:</b><br>Device (config-flow-record) # <b>match ipv4</b><br><b>protocol</b>           | Specifies a match to the IPv4 protocol.                   |
| <b>Step 6</b> | <b>match application name</b>                                                                                                     | Specifies a match to the application name.                |

|                | Command or Action                                                                                                                              | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | <b>Example:</b><br>Device (config-flow-record)# <b>match application name</b>                                                                  | <b>Note</b> This action is mandatory for AVC support, as this allows the flow to be matched against the application.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Step 7</b>  | <b>match connection client ipv4 address</b><br><b>Example:</b><br>Device (config-flow-record)# <b>match connection client ipv4 address</b>     | Specifies a match to the IPv4 address of the client (flow initiator).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Step 8</b>  | <b>match connection server ipv4 address</b><br><b>Example:</b><br>Device (config-flow-record)# <b>match connection server ipv4 address</b>     | Specifies a match to the IPv4 address of the server (flow responder).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Step 9</b>  | <b>match connection server transport port</b><br><b>Example:</b><br>Device (config-flow-record)# <b>match connection server transport port</b> | Specifies a match to the transport port of the server.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Step 10</b> | <b>match flow observation point</b><br><b>Example:</b><br>Device (config-flow-record)# <b>match flow observation point</b>                     | Specifies a match to the observation point ID for flow observation metrics.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Step 11</b> | <b>collect flow direction</b><br><b>Example:</b><br>Device (config-flow-record)# <b>collect flow direction</b>                                 | <p>Specifies to collect the direction — Ingress or Egress — of the relevant side — Initiator or Responder — of the bi-directional flow that is specified by the <b>initiator</b> keyword in the <b>collect connection initiator</b> command in the step below. Depending on the value specified by the <b>initiator</b> keyword, the <b>flow direction</b> keyword takes the following values :</p> <ul style="list-style-type: none"> <li>• 0x01 = Ingress Flow</li> <li>• 0x02 = Egress Flow</li> </ul> <p>When the <b>initiator</b> keyword is set to initiator, the flow direction is specified from the initiator side of the flow. When the initiator keyword is set to responder, the flow direction is specified from the responder side of the flow. For wired AVC, the <b>initiator</b> keyword is always set to initiator.</p> |
| <b>Step 12</b> | <b>collect connection initiator</b><br><b>Example:</b><br>Device (config-flow-record)# <b>collect connection initiator</b>                     | Specifies to collect the side of the flow — Initiator or Responder — relevant to the direction of the flow specified by the <b>collect flow direction</b> command. The <b>initiator</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

|                | Command or Action                                                                                                                                                                      | Purpose                                                                                                                                                                                                                                                                                      |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                |                                                                                                                                                                                        | <p>keyword provides the following information about the direction of the flow :</p> <ul style="list-style-type: none"> <li>• 0x01 = Initiator - the flow source is the initiator of the connection</li> </ul> <p>For wired AVC, the <b>initiator</b> keyword is always set to initiator.</p> |
| <b>Step 13</b> | <p><b>collect connection client counter packets long</b></p> <p><b>Example:</b></p> <pre>Device (config-flow-record)# collect connection client counter packets long</pre>             | Specifies to collect the number of packets sent by the client.                                                                                                                                                                                                                               |
| <b>Step 14</b> | <p><b>collect connection client counter bytes network long</b></p> <p><b>Example:</b></p> <pre>Device (config-flow-record)# collect connection client counter bytes network long</pre> | Specifies to collect the total number of bytes transmitted by the client.                                                                                                                                                                                                                    |
| <b>Step 15</b> | <p><b>collect connection server counter packets long</b></p> <p><b>Example:</b></p> <pre>Device (config-flow-record)# collect connection server counter packets long</pre>             | Specifies to collect the number of packets sent by the server.                                                                                                                                                                                                                               |
| <b>Step 16</b> | <p><b>collect connection server counter bytes network long</b></p> <p><b>Example:</b></p> <pre>Device (config-flow-record)# collect connection server counter bytes network long</pre> | Specifies to collect the total number of bytes transmitted by the server.                                                                                                                                                                                                                    |
| <b>Step 17</b> | <p><b>collect timestamp absolute first</b></p> <p><b>Example:</b></p> <pre>Device (config-flow-record)# collect timestamp absolute first</pre>                                         | Specifies to collect the time, in milliseconds, when the first packet was seen in the flow.                                                                                                                                                                                                  |
| <b>Step 18</b> | <p><b>collect timestamp absolute last</b></p> <p><b>Example:</b></p> <pre>Device (config-flow-record)# collect timestamp absolute last</pre>                                           | Specifies to collect the time, in milliseconds, when the most recent packet was seen in the flow.                                                                                                                                                                                            |
| <b>Step 19</b> | <p><b>collect connection new-connections</b></p> <p><b>Example:</b></p> <pre>Device (config-flow-record)# collect connection new-connections</pre>                                     | Specifies to collect the number of connection initiations observed.                                                                                                                                                                                                                          |

|                | Command or Action                                                              | Purpose                                                                                                             |
|----------------|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| <b>Step 20</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b>                    | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |
| <b>Step 21</b> | <b>show flow record</b><br><b>Example:</b><br>Device # <b>show flow record</b> | Displays information about all the flow records.                                                                    |

## Creating a Flow Exporter

You can create a flow exporter to define the export parameters for a flow.

### Procedure

|               | Command or Action                                                                                                                                                       | Purpose                                                                                                                                                                                                      |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                                                       | Enters global configuration mode.                                                                                                                                                                            |
| <b>Step 2</b> | <b>flow exporter <i>flow_exporter_name</i></b><br><b>Example:</b><br>Device(config)# <b>flow exporter</b><br><b>flow-exporter-1</b>                                     | Enters flow exporter configuration mode.                                                                                                                                                                     |
| <b>Step 3</b> | <b>description <i>description</i></b><br><b>Example:</b><br>Device(config-flow-exporter)# <b>description</b><br><b>flow-exporter-1</b>                                  | (Optional) Creates a description for the flow exporter.                                                                                                                                                      |
| <b>Step 4</b> | <b>destination { <i>hostname</i>   <i>ipv4-address</i>   <i>ipv6-address</i> }</b><br><b>Example:</b><br>Device (config-flow-exporter)#<br><b>destination 10.10.1.1</b> | Specifies the hostname, IPv4 or IPv6 address of the system to which the exporter sends data.                                                                                                                 |
| <b>Step 5</b> | <b>option application-table [ <i>timeout seconds</i> ]</b><br><b>Example:</b><br>Device (config-flow-exporter)# <b>option</b><br><b>application-table timeout 500</b>   | (Optional) Configures the application table option for the flow exporter. The <b>timeout</b> option configures the resend time in seconds for the flow exporter. The valid range is from 1 to 86400 seconds. |
| <b>Step 6</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b>                                                                                                             | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                                          |

|               | Command or Action                                                                                        | Purpose                                            |
|---------------|----------------------------------------------------------------------------------------------------------|----------------------------------------------------|
| <b>Step 7</b> | <b>show flow exporter</b><br><b>Example:</b><br>Device # <b>show flow exporter</b>                       | Displays information about all the flow exporters. |
| <b>Step 8</b> | <b>show flow exporter statistics</b><br><b>Example:</b><br>Device # <b>show flow exporter statistics</b> | Displays flow exporter statistics.                 |

## Creating a Flow Monitor

You can create a flow monitor and associate it with a flow record.

### Procedure

|               | Command or Action                                                                                                                                                                                                                      | Purpose                                                                                                                                                                                                                                            |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                                                                                                                      | Enters global configuration mode.                                                                                                                                                                                                                  |
| <b>Step 2</b> | <b>flow monitor <i>monitor-name</i></b><br><b>Example:</b><br>Device (config)# <b>flow monitor</b><br>flow-monitor-1                                                                                                                   | Creates a flow monitor and enters flow monitor configuration mode.                                                                                                                                                                                 |
| <b>Step 3</b> | <b>description <i>description</i></b><br><b>Example:</b><br>Device (config-flow-monitor)#<br><b>description</b> flow-monitor-1                                                                                                         | (Optional) Creates a description for the flow monitor.                                                                                                                                                                                             |
| <b>Step 4</b> | <b>record <i>record-name</i></b><br><b>Example:</b><br>Device (config-flow-monitor)# <b>record</b><br>flow-record-1                                                                                                                    | Specifies the name of a record that was created previously.                                                                                                                                                                                        |
| <b>Step 5</b> | <b>exporter <i>exporter-name</i></b><br><b>Example:</b><br>Device (config-flow-monitor)# <b>exporter</b><br>flow-exporter-1                                                                                                            | Specifies the name of an exporter that was created previously.                                                                                                                                                                                     |
| <b>Step 6</b> | <b>cache { <b>entries</b> <i>number-of-entries</i>   <b>timeout</b> {<b>active</b>   <b>inactive</b>}   <b>type</b> <b>normal</b> }</b><br><b>Example:</b><br>Device (config-flow-monitor)# <b>cache</b><br><b>timeout active 1800</b> | (Optional) Specifies to configure flow cache parameters. <ul style="list-style-type: none"> <li><b>entries</b> <i>number-of-entries</i> — Specifies the maximum number of flow entries in the flow cache in the range from 16 to 65536.</li> </ul> |



|                | Command or Action                                                                                                                                                                  | Purpose                                                                                                                                                                                                                                        |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | <p><b>Example:</b></p> <pre>Device (config-flow-monitor)# cache timeout inactive 200</pre> <p><b>Example:</b></p> <pre>Device (config-flow-monitor)# cache type normal</pre>       | <p><b>Note</b> Only normal cache type is supported.</p>                                                                                                                                                                                        |
| <b>Step 7</b>  | <p><b>end</b></p> <p><b>Example:</b></p> <pre>Device (config)# end</pre>                                                                                                           | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                                                                            |
| <b>Step 8</b>  | <p><b>show flow monitor</b></p> <p><b>Example:</b></p> <pre>Device # show flow monitor</pre>                                                                                       | Displays information about all the flow monitors.                                                                                                                                                                                              |
| <b>Step 9</b>  | <p><b>show flow monitor</b> <i>flow-monitor-name</i></p> <p><b>Example:</b></p> <pre>Device # show flow monitor flow-monitor-1</pre>                                               | Displays information about the specified wired AVC flow monitor.                                                                                                                                                                               |
| <b>Step 10</b> | <p><b>show flow monitor</b> <i>flow-monitor-name</i> <b>statistics</b></p> <p><b>Example:</b></p> <pre>Device# show flow monitor flow-monitor-1 statistics</pre>                   | Displays statistics for wired AVC flow monitor.                                                                                                                                                                                                |
| <b>Step 11</b> | <p><b>clear flow monitor</b> <i>flow-monitor-name</i> <b>statistics</b></p> <p><b>Example:</b></p> <pre>Device# clear flow monitor flow-monitor-1 statistics</pre>                 | Clears the statistics of the specified flow monitor. Use the <b>show flow monitor flow-monitor-1 statistics</b> command after using the <b>clear flow monitor flow-monitor-1 statistics</b> to verify that all the statistics have been reset. |
| <b>Step 12</b> | <p><b>show flow monitor</b> <i>flow-monitor-name</i> <b>cache format table</b></p> <p><b>Example:</b></p> <pre>Device# show flow monitor flow-monitor-1 cache format table</pre>   | Displays flow cache contents in a tabular format.                                                                                                                                                                                              |
| <b>Step 13</b> | <p><b>show flow monitor</b> <i>flow-monitor-name</i> <b>cache format record</b></p> <p><b>Example:</b></p> <pre>Device# show flow monitor flow-monitor-1 cache format record</pre> | Displays flow cache contents in similar format as the flow record.                                                                                                                                                                             |
| <b>Step 14</b> | <p><b>show flow monitor</b> <i>flow-monitor-name</i> <b>cache format csv</b></p>                                                                                                   | Displays flow cache contents in CSV format.                                                                                                                                                                                                    |

|  | Command or Action                                                                         | Purpose |
|--|-------------------------------------------------------------------------------------------|---------|
|  | <b>Example:</b><br>Device# <code>show flow monitor flow-monitor-1 cache format csv</code> |         |

## Associating Flow Monitor to an interface

### Procedure

|               | Command or Action                                                                                                                                              | Purpose                                                                                                             |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><br><b>Example:</b><br>Device# <code>configure terminal</code>                                                                    | Enters global configuration mode.                                                                                   |
| <b>Step 2</b> | <b>interface <i>interface-id</i></b><br><br><b>Example:</b><br>Device(config)# <code>interface GigabitEthernet 1/0/1</code>                                    | Enters the interface configuration mode.                                                                            |
| <b>Step 3</b> | <b>ip flow monitor <i>monitor-name</i> { input   output }</b><br><br><b>Example:</b><br>Device (config-if) # <code>ip flow monitor flow-monitor-1 input</code> | Associates a flow monitor to the interface for input and/or output packets.                                         |
| <b>Step 4</b> | <b>end</b><br><br><b>Example:</b><br>Device (config) # <code>end</code>                                                                                        | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

## NBAR2 Custom Applications

NBAR2 supports the use of custom protocols to identify custom applications. Custom protocols support protocols and applications that NBAR2 does not currently support.

In every deployment, there are local and specific applications which are not covered by the NBAR2 protocol pack provided by Cisco. Local applications are mainly categorized as:

- Specific applications to an organization
- Applications specific to a geography

NBAR2 provides a way to manually customize such local applications. You can manually customize applications using the command **ip nbar custom *myappname*** in global configuration mode. Custom applications take precedence over built-in protocols. For each custom protocol, user can define a selector ID that can be used for reporting purposes.

There are various types of application customization:

### Generic protocol customization

- HTTP
- SSL
- DNS

**Composite** : Customization based on multiple underlying protocols – **server-name**

### Layer3/Layer4 customization

- IPv4 address
- DSCP values
- TCP/UDP ports
- Flow source or destination direction

**Byte Offset** : Customization based on specific byte values in the payload

## HTTP Customization

HTTP customization could be based on a combination of HTTP fields from:

- **cookie** - HTTP Cookie
- **host** - Host name of Origin Server containing resource
- **method** - HTTP method
- **referrer** - Address the resource request was obtained from
- **url** - Uniform Resource Locator path
- **user-agent** - Software used by agent sending the request
- **version** - HTTP version
- **via** - HTTP via field

### HTTP Customization

Custom application called MYHTTP using the HTTP host “\*mydomain.com” with Selector ID 10.

```
Device# configure terminal
Device(config)# ip nbar custom MYHTTP http host *mydomain.com id 10
```

## SSL Customization

Customization can be done for SSL encrypted traffic using information extracted from the SSL Server Name Indication (SNI) or Common Name (CN).

### SSL Customization

Custom application called MYSSL using SSL unique-name “mydomain.com” with selector ID 11.

```
Device# configure terminal
Device(config)#ip nbar custom MYSSL ssl unique-name *mydomain.com id 11
```

## DNS Customization

NBAR2 examines DNS request and response traffic, and can correlate the DNS response to an application. The IP address returned from the DNS response is cached and used for later packet flows associated with that specific application.

The command **ip nbar custom *application-name* dns *domain-name* id *application-id*** is used for DNS customization. To extend an existing application, use the command **ip nbar custom *application-name* dns *domain-name* *domain-name* extends *existing-application***.

For more information on DNS based customization, see [http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/qos\\_nbar/configuration/xs/asr1000/qos-nbar-xe-3s-asr-1000-book/nbar-custapp-dns-xe.html](http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/qos_nbar/configuration/xs/asr1000/qos-nbar-xe-3s-asr-1000-book/nbar-custapp-dns-xe.html).

### DNS Customization

Custom application called MYDNS using the DNS domain name “mydomain.com” with selector ID 12.

```
Device# configure terminal
Device(config)# ip nbar custom MYDNS dns domain-name *mydomain.com id 12
```

## Composite Customization

NBAR2 provides a way to customize applications based on domain names appearing in HTTP, SSL or DNS.

### Composite Customization

Custom application called MYDOMAIN using HTTP, SSL or DNS domain name “mydomain.com” with selector ID 13.

```
Device# configure terminal
Device(config)# ip nbar custom MYDOMAIN composite server-name *mydomain.com id 13
```

## L3/L4 Customization

Layer3/Layer4 customization is based on the packet tuple and is always matched on the first packet of a flow.

### L3/L4 Customization

Custom application called LAYER4CUSTOM matching IP addresses 10.56.1.10 and 10.56.1.11, TCP and DSCP ef with selector ID 14.

```
Device# configure terminal
Device(config)# ip nbar custom LAYER4CUSTOM transport tcp id 14
Device(config-custom)# ip address 10.56.1.10 10.56.1.11
Device(config-custom)# dscp ef
```

## Examples: Monitoring Custom Applications

### Show Commands for Monitoring Custom Applications

#### show ip nbar protocol-id | inc Custom

```
Device# show ip nbar protocol-id | inc Custom
LAYER4CUSTOM          14          Custom
MYDNS                 12          Custom
MYDOMAIN              13          Custom
MYHTTP                10          Custom
MYSSL                 11          Custom
```

#### show ip nbar protocol-discovery protocol CUSTOM\_APP

```
WSW-157# show ip nbar protocol-id MYSSL
Protocol Name          id          type
-----
MYSSL                  11          Custom
```

## NBAR2 Dynamic Hitless Protocol Pack Upgrade

Protocol packs are software packages that update the NBAR2 protocol support on a device without replacing the Cisco software on the device. A protocol pack contains information on applications officially supported by NBAR2 which are compiled and packed together. For each application, the protocol-pack includes information on application signatures and application attributes. Each software release has a built-in protocol-pack bundled with it.

Protocol packs provide the following features:

- They are easy and fast to load.
- They are easy to upgrade to a higher version protocol pack or revert to a lower version protocol pack.
- They do not require the switch to be reloaded.

NBAR2 protocol packs are available for download on Cisco Software Center from this URL:  
<https://software.cisco.com/download/navigator.html> .

### Prerequisites for the NBAR2 Protocol Pack

Before loading a new protocol pack, you must copy the protocol pack to the flash on all the switch members.

To load a protocol pack, see [Examples: Loading the NBAR2 Protocol Pack, on page 2520](#) .

### Loading the NBAR2 Protocol Pack

#### Procedure

|               | Command or Action                | Purpose                                                                                                            |
|---------------|----------------------------------|--------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>enable</b><br><b>Example:</b> | Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul> |

|               | Command or Action                                                                                                                                                                                            | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | Device> enable                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Step 2</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# configure terminal                                                                                                                                   | Enters global configuration mode.                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Step 3</b> | <b>ip nbar protocol-pack <i>protocol-pack</i> [force]</b><br><b>Example:</b><br>Device(config)# ip nbar protocol-pack flash:defProtoPack<br><b>Example:</b><br>Device(config)# default ip nbar protocol-pack | Loads the protocol pack.<br><ul style="list-style-type: none"><li>• Use the <b>force</b> keyword to specify and load a protocol pack of a lower version, which is different from the base protocol pack version. This also removes the configuration that is not supported by the current protocol pack on the switch.</li></ul> For reverting to the built-in protocol pack, use the following command:                                                                     |
| <b>Step 4</b> | <b>exit</b><br><b>Example:</b><br>Device(config)# exit                                                                                                                                                       | Returns to privileged EXEC mode.                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Step 5</b> | <b>show ip nbar protocol-pack {protocol-pack   active} [detail]</b><br><b>Example:</b><br>Device# show ip nbar protocol-pack active                                                                          | Displays the protocol pack information.<br><ul style="list-style-type: none"><li>• Verify the loaded protocol pack version, publisher, and other details using this command.</li><li>• Use the <i>protocol-pack</i> argument to display information about the specified protocol pack.</li><li>• Use the <b>active</b> keyword to display active protocol pack information.</li><li>• Use the <b>detail</b> keyword to display detailed protocol pack information.</li></ul> |

### Examples: Loading the NBAR2 Protocol Pack

The following example shows how to load a new protocol pack:

```
Device> enable
Device# configure terminal
Device(config)# ip nbar protocol-pack flash:newDefProtoPack
Device(config)# exit
```

The following example shows how to use the **force** keyword to load a protocol pack of a lower version:

```
Device> enable
Device# configure terminal
```

```
Device(config)# ip nbar protocol-pack flash:OldDefProtoPack force
Device(config)# exit
```

The following example shows how to revert to the built-in protocol pack:

```
Device> enable
Device# configure terminal
Device(config)# default ip nbar protocol-pack
Device(config)# exit
```

# Monitoring Application Visibility and Control

## Monitoring Application Visibility and Control (CLI)

This section describes the new commands for application visibility.

The following commands can be used to monitor application visibility on the and access ports.

**Table 199: Monitoring Application Visibility Commands on the**

| Command                                                                                                                                                                                                               | Purpose                                                                                                                                                                                                                                                                                                                                 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>show ip nbar protocol-discovery</b> [ <i>interface interface-type interface-number</i> ]<br>[ <i>stats{byte-count   bit-rate   packet-count   max-bit-rate}</i> ] [ <i>protocol protocol-name   top-n number</i> ] | Displays the statistics gathered by the NBAR Protocol Discovery feature.<br><br>• (Optional) Enter keywords and arguments to fine-tune the statistics displayed. For more information on each of the keywords, refer to the <b>show ip nbar protocol-discovery</b> command in Cisco IOS Quality of Service Solutions Command Reference. |
| <b>show policy-map interface</b> <i>interface-type interface-number</i>                                                                                                                                               | Displays information about policy map applied to the interface.                                                                                                                                                                                                                                                                         |
| <b>show platform software fed switch</b> <i>switch id</i><br><b>wdavc flows</b>                                                                                                                                       | Displays statistics about all flows on the specified switch.                                                                                                                                                                                                                                                                            |

## Examples: Application Visibility and Control

### Examples: Application Visibility and Control Configuration

This example shows how to create class maps with apply match protocol filters for application name:

```
Device# configure terminal
Device(config)# class-map match-any NBAR-VOICE
Device(config-cmap)# match protocol ms-lync-audio
Device(config-cmap)#end
```

This example shows how to create policy maps and define existing class maps for egress QoS:

```
Device# configure terminal
Device(config)# policy-map test-avc-up
```

```
Device(config-pmap) # class cat-browsing
Device(config-pmap-c) # police 150000
Device(config-pmap-c) # set dscp 12
Device(config-pmap-c) #end
```

This example shows how to create policy maps and define existing class maps for ingress QoS:

```
Device# configure terminal
Device(config) # policy-map test-avc-down
Device(config-pmap) # class cat-browsing
Device(config-pmap-c) # police 200000
Device(config-pmap-c) # set dscp 10
Device(config-pmap-c) #end
```

This example shows how to apply policy maps to a switch port:

```
Device# configure terminal
Device(config) # interface GigabitEthernet 1/0/1
Device(config-if) # switchport mode access
Device(config-if) # switchport access vlan 20
Device(config-if) # service-policy input POLICING_IN
Device(config-if) #end
```

### Show Commands for Viewing the Configuration

#### show ip nbar protocol-discovery

Displays a report of the Protocol Discovery statistics per interface.

The following is a sample output for the statistics per interface:

```
Deviceqos-cat9k-reg2-r1# show ip nbar protocol-discovery int GigabitEthernet1/0/1
```

```
GigabitEthernet1/0/1
Last clearing of "show ip nbar protocol-discovery" counters 00:03:16

Output
-----
Protocol          Packet Count
Packet Count      Byte Count
Byte Count        30sec Bit Rate (bps)
30sec Bit Rate (bps)  30sec Max Bit Rate (bps)
30sec Max Bit Rate (bps)
-----
ms-lync           60580
55911             31174777
28774864          3613000
93000             3613000
3437000
```



```

Total                                     60580
55911                                     31174777
28774864                                  3613000
93000                                     3613000
3437000

```

### show policy-map interface

Displays the QoS statistics and the configured policy maps on all interfaces.

The following is a sample output for the policy-maps configured on all the interfaces:

```

Deviceqos-cat9k-reg2-r1# show policy-map int

GigabitEthernet1/0/1
  Service-policy input: MARKING-IN

    Class-map: NBAR-VOICE (match-any)
      718 packets
      Match: protocol ms-lync-audio
        0 packets, 0 bytes
        30 second rate 0 bps
      QoS Set
        dscp ef

    Class-map: NBAR-MM_CONFERENCING (match-any)
      6451 packets
      Match: protocol ms-lync
        0 packets, 0 bytes
        30 second rate 0 bps
      Match: protocol ms-lync-video
        0 packets, 0 bytes
        30 second rate 0 bps
      QoS Set
        dscp af41

    Class-map: class-default (match-any)
      34 packets
      Match: any

```

### Show Commands for Viewing Flow Monitor Configuration

#### show flow monitor wдавс

Displays information about the specified wired AVC flow monitor.

```

Device # show flow monitor wдавс

Flow Monitor wдавс:
  Description:      User defined
  Flow Record:     wдавс
  Flow Exporter:   wдавс-exp (inactive)

```

```

Cache:
  Type:          normal (Platform cache)
  Status:       not allocated
  Size:         12000 entries
  Inactive Timeout: 15 secs
  Active Timeout: 1800 secs

```

### show flow monitor wdacv statistics

Displays statistics for wired AVC flow monitor.

```

Device# show flow monitor wdacv statistics
Cache type:          Normal (Platform cache)
Cache size:         12000
Current entries:    13

Flows added:        26
Flows aged:         13
  - Active timeout   ( 1800 secs)   1
  - Inactive timeout (   15 secs)   12

```

### clear flow monitor wdacv statistics

Clears the statistics of the specified flow monitor. Use the **show flow monitor wdacv statistics** command after using the **clear flow monitor wdacv statistics** to verify that all the statistics have been reset. The following is a sample output of the **show flow monitor wdacv statistics** command after clearing flow monitor statistics.

```

Device# show flow monitor wdacv statistics
Cache type:          Normal (Platform cache)
Cache size:         12000
Current entries:    0

Flows added:        0
Flows aged:         0

```

### Show Commands for Viewing Cache Contents

#### show flow monitor wdacv cache format table

Displays flow cache contents in a tabular format.

```

Device# show flow monitor wdacv cache format table
Cache type:          Normal (Platform cache)
Cache size:         12000
Current entries:    13

Flows added:        26
Flows aged:         13
  - Active timeout   ( 1800 secs)   1
  - Inactive timeout (   15 secs)   12

CONN IPV4 INITIATOR ADDR  CONN IPV4 RESPONDER ADDR  CONN RESPONDER PORT
FLOW OBSPOINT ID  IP VERSION  IP PROT  APP NAME                flow
dirn .....
-----
-----

```

```

-----
64.103.125.147          144.254.71.184          53
    4294967305          4          17 port dns          Input
.....
64.103.121.103         10.1.1.2                67
    4294967305          4          17 layer7 dhcp          Input
....contd.....
64.103.125.3           64.103.125.97           68
    4294967305          4          17 layer7 dhcp          Input
.....
10.0.2.6               157.55.40.149           443
    4294967305          4          6 layer7 ms-lync        Input
.....
64.103.126.28          66.163.36.139           443
    4294967305          4          6 layer7 cisco-jabber-im Input
....contd.....
64.103.125.2           64.103.125.29           68
    4294967305          4          17 layer7 dhcp          Input
.....
64.103.125.97          64.103.101.181          67
    4294967305          4          17 layer7 dhcp          Input
.....
192.168.100.6          10.10.20.1              5060
    4294967305          4          17 layer7 cisco-jabber-control Input
....contd.....
64.103.125.3           64.103.125.29           68
    4294967305          4          17 layer7 dhcp          Input
.....
10.80.101.18           10.80.101.6             5060
    4294967305          4          6 layer7 cisco-collab-control Input
.....
10.1.11.4              66.102.11.99            80
    4294967305          4          6 layer7 google-services Input
....contd.....
64.103.125.2           64.103.125.97           68
    4294967305          4          17 layer7 dhcp          Input
.....
64.103.125.29          64.103.101.181          67
    4294967305          4          17 layer7 dhcp          Input
.....

```

### show flow monitor wdvac cache format record

Displays flow cache contents in similar format as the flow record.

```

Device# show flow monitor wdvac cache format record
Cache type:                Normal (Platform cache)
Cache size:                 12000
Current entries:            13

Flows added:                26
Flows aged:                 13
- Active timeout           ( 1800 secs)  1

```

```

- Inactive timeout      (    15 secs)           12

CONNECTION IPV4 INITIATOR ADDRESS:      64.103.125.147
CONNECTION IPV4 RESPONDER ADDRESS:     144.254.71.184
CONNECTION RESPONDER PORT:             53
FLOW OBSPOINT ID:                     4294967305
IP VERSION:                            4
IP PROTOCOL:                           17
APPLICATION NAME:                       port dns
flow direction:                         Input
timestamp abs first:                    08:55:46.917
timestamp abs last:                     08:55:46.917
connection initiator:                   Initiator
connection count new:                   2
connection server packets counter:      1
connection client packets counter:      1
connection server network bytes counter: 190
connection client network bytes counter: 106

CONNECTION IPV4 INITIATOR ADDRESS:      64.103.121.103
CONNECTION IPV4 RESPONDER ADDRESS:     10.1.1.2
CONNECTION RESPONDER PORT:             67
FLOW OBSPOINT ID:                     4294967305
IP VERSION:                            4
IP PROTOCOL:                           17
APPLICATION NAME:                       layer7 dhcp
flow direction:                         Input
timestamp abs first:                    08:55:47.917
timestamp abs last:                     08:55:47.917
connection initiator:                   Initiator
connection count new:                   1
connection server packets counter:      0
connection client packets counter:      1
connection server network bytes counter: 0
connection client network bytes counter: 350

CONNECTION IPV4 INITIATOR ADDRESS:      64.103.125.3
CONNECTION IPV4 RESPONDER ADDRESS:     64.103.125.97
CONNECTION RESPONDER PORT:             68
FLOW OBSPOINT ID:                     4294967305
IP VERSION:                            4
IP PROTOCOL:                           17
APPLICATION NAME:                       layer7 dhcp
flow direction:                         Input
timestamp abs first:                    08:55:47.917
timestamp abs last:                     08:55:53.917
connection initiator:                   Initiator
connection count new:                   1
connection server packets counter:      0
connection client packets counter:      4
connection server network bytes counter: 0

```

```
connection client network bytes counter: 1412

CONNECTION IPV4 INITIATOR ADDRESS: 10.0.2.6
CONNECTION IPV4 RESPONDER ADDRESS: 157.55.40.149
CONNECTION RESPONDER PORT: 443
FLOW OBSPOINT ID: 4294967305
IP VERSION: 4
IP PROTOCOL: 6
APPLICATION NAME: layer7 ms-lync
flow direction: Input
timestamp abs first: 08:55:46.917
timestamp abs last: 08:55:46.917
connection initiator: Initiator
connection count new: 2
connection server packets counter: 10
connection client packets counter: 14
connection server network bytes counter: 6490
connection client network bytes counter: 1639

CONNECTION IPV4 INITIATOR ADDRESS: 64.103.126.28
CONNECTION IPV4 RESPONDER ADDRESS: 66.163.36.139
CONNECTION RESPONDER PORT: 443
FLOW OBSPOINT ID: 4294967305
IP VERSION: 4
IP PROTOCOL: 6
APPLICATION NAME: layer7 cisco-jabber-im
flow direction: Input
timestamp abs first: 08:55:46.917
timestamp abs last: 08:55:46.917
connection initiator: Initiator
connection count new: 2
connection server packets counter: 12
connection client packets counter: 10
connection server network bytes counter: 5871
connection client network bytes counter: 2088

CONNECTION IPV4 INITIATOR ADDRESS: 64.103.125.2
CONNECTION IPV4 RESPONDER ADDRESS: 64.103.125.29
CONNECTION RESPONDER PORT: 68
FLOW OBSPOINT ID: 4294967305
IP VERSION: 4
IP PROTOCOL: 17
APPLICATION NAME: layer7 dhcp
flow direction: Input
timestamp abs first: 08:55:47.917
timestamp abs last: 08:55:47.917
connection initiator: Initiator
connection count new: 1
connection server packets counter: 0
connection client packets counter: 2
connection server network bytes counter: 0
```

```
connection client network bytes counter: 712

CONNECTION IPV4 INITIATOR ADDRESS: 64.103.125.97
CONNECTION IPV4 RESPONDER ADDRESS: 64.103.101.181
CONNECTION RESPONDER PORT: 67
FLOW OBSPOINT ID: 4294967305
IP VERSION: 4
IP PROTOCOL: 17
APPLICATION NAME: layer7 dhcp
flow direction: Input
timestamp abs first: 08:55:47.917
timestamp abs last: 08:55:47.917
connection initiator: Initiator
connection count new: 1
connection server packets counter: 0
connection client packets counter: 1
connection server network bytes counter: 0
connection client network bytes counter: 350

CONNECTION IPV4 INITIATOR ADDRESS: 192.168.100.6
CONNECTION IPV4 RESPONDER ADDRESS: 10.10.20.1
CONNECTION RESPONDER PORT: 5060
FLOW OBSPOINT ID: 4294967305
IP VERSION: 4
IP PROTOCOL: 17
APPLICATION NAME: layer7 cisco-jabber-control
flow direction: Input
timestamp abs first: 08:55:46.917
timestamp abs last: 08:55:46.917
connection initiator: Initiator
connection count new: 1
connection server packets counter: 0
connection client packets counter: 2
connection server network bytes counter: 0
connection client network bytes counter: 2046

CONNECTION IPV4 INITIATOR ADDRESS: 64.103.125.3
CONNECTION IPV4 RESPONDER ADDRESS: 64.103.125.29
CONNECTION RESPONDER PORT: 68
FLOW OBSPOINT ID: 4294967305
IP VERSION: 4
IP PROTOCOL: 17
APPLICATION NAME: layer7 dhcp
flow direction: Input
timestamp abs first: 08:55:47.917
timestamp abs last: 08:55:47.917
connection initiator: Initiator
connection count new: 1
connection server packets counter: 0
connection client packets counter: 2
connection server network bytes counter: 0
```

```
connection client network bytes counter: 712

CONNECTION IPV4 INITIATOR ADDRESS: 10.80.101.18
CONNECTION IPV4 RESPONDER ADDRESS: 10.80.101.6
CONNECTION RESPONDER PORT: 5060
FLOW OBSPOINT ID: 4294967305
IP VERSION: 4
IP PROTOCOL: 6
APPLICATION NAME: layer7 cisco-collab-control
flow direction: Input
timestamp abs first: 08:55:46.917
timestamp abs last: 08:55:47.917
connection initiator: Initiator
connection count new: 2
connection server packets counter: 23
connection client packets counter: 27
connection server network bytes counter: 12752
connection client network bytes counter: 8773

CONNECTION IPV4 INITIATOR ADDRESS: 10.1.11.4
CONNECTION IPV4 RESPONDER ADDRESS: 66.102.11.99
CONNECTION RESPONDER PORT: 80
FLOW OBSPOINT ID: 4294967305
IP VERSION: 4
IP PROTOCOL: 6
APPLICATION NAME: layer7 google-services
flow direction: Input
timestamp abs first: 08:55:46.917
timestamp abs last: 08:55:46.917
connection initiator: Initiator
connection count new: 2
connection server packets counter: 3
connection client packets counter: 5
connection server network bytes counter: 1733
connection client network bytes counter: 663

CONNECTION IPV4 INITIATOR ADDRESS: 64.103.125.2
CONNECTION IPV4 RESPONDER ADDRESS: 64.103.125.97
CONNECTION RESPONDER PORT: 68
FLOW OBSPOINT ID: 4294967305
IP VERSION: 4
IP PROTOCOL: 17
APPLICATION NAME: layer7 dhcp
flow direction: Input
timestamp abs first: 08:55:47.917
timestamp abs last: 08:55:53.917
connection initiator: Initiator
connection count new: 1
connection server packets counter: 0
connection client packets counter: 4
connection server network bytes counter: 0
```

```

connection client network bytes counter: 1412

CONNECTION IPV4 INITIATOR ADDRESS:      64.103.125.29
CONNECTION IPV4 RESPONDER ADDRESS:     64.103.101.181
CONNECTION RESPONDER PORT:             67
FLOW OBSPOINT ID:                      4294967305
IP VERSION:                             4
IP PROTOCOL:                            17
APPLICATION NAME:                       layer7 dhcp
flow direction:                         Input
timestamp abs first:                   08:55:47.917
timestamp abs last:                    08:55:47.917
connection initiator:                   Initiator
connection count new:                   1
connection server packets counter:     0
connection client packets counter:     1
connection server network bytes counter: 0
connection client network bytes counter: 350

```

### show flow monitor wdavc cache format csv

Displays flow cache contents in CSV format.

```

Device# show flow monitor wdavc cache format csv
Cache type:                               Normal (Platform cache)
Cache size:                               12000
Current entries:                           13

Flows added:                              26
Flows aged:                                13
- Active timeout      ( 1800 secs)         1
- Inactive timeout    (   15 secs)         12

```

```

CONN IPV4 INITIATOR ADDR,CONN IPV4 RESPONDER ADDR,CONN RESPONDER PORT,FLOW
OBSPOINT ID,IP VERSION,IP
PROT,APP NAME,flow dirn,time abs first,time abs last,conn initiator,conn
count new,conn server packets
cnt,conn client packets cnt,conn server network bytes cnt,conn client
network bytes cnt
64.103.125.147,144.254.71.184,53,4294967305,4,17,port
dns,Input,08:55:46.917,08:55:46.917,Initiator,2,1,1,190,106
64.103.121.103,10.1.1.2,67,4294967305,4,17,layer7
dhcp,Input,08:55:47.917,08:55:47.917,Initiator,1,0,1,0,350
64.103.125.3,64.103.125.97,68,4294967305,4,17,layer7
dhcp,Input,08:55:47.917,08:55:53.917,Initiator,1,0,4,0,1412
10.0.2.6,157.55.40.149,443,4294967305,4,6,layer7 ms-
lync,Input,08:55:46.917,08:55:46.917,Initiator,2,10,14,6490,1639
64.103.126.28,66.163.36.139,443,4294967305,4,6,layer7 cisco-jabber-
im,Input,08:55:46.917,08:55:46.917,Initiator,2,12,10,5871,2088
64.103.125.2,64.103.125.29,68,4294967305,4,17,layer7
dhcp,Input,08:55:47.917,08:55:47.917,Initiator,1,0,2,0,712
64.103.125.97,64.103.101.181,67,4294967305,4,17,layer7
dhcp,Input,08:55:47.917,08:55:47.917,Initiator,1,0,1,0,350

```



```
192.168.100.6,10.10.20.1,5060,4294967305,4,17,layer7 cisco-jabber-  
control,Input,08:55:46.917,08:55:46.917,Initiator,1,0,2,0,2046  
64.103.125.3,64.103.125.29,68,4294967305,4,17,layer7  
dhcp,Input,08:55:47.917,08:55:47.917,Initiator,1,0,2,0,712  
10.80.101.18,10.80.101.6,5060,4294967305,4,6,layer7 cisco-collab-  
control,Input,08:55:46.917,08:55:47.917,Initiator,2,23,27,12752,8773  
10.1.11.4,66.102.11.99,80,4294967305,4,6,layer7 google-  
services,Input,08:55:46.917,08:55:46.917,Initiator,2,3,5,1733,663  
64.103.125.2,64.103.125.97,68,4294967305,4,17,layer7  
dhcp,Input,08:55:47.917,08:55:53.917,Initiator,1,0,4,0,1412  
64.103.125.29,64.103.101.181,67,4294967305,4,17,layer7  
dhcp,Input,08:55:47.917,08:55:47.917,Initiator,1,0,1,0,350
```

## Basic Troubleshooting(Questions and Answers)

Following are the basic questions and answers for troubleshooting wired Application Visibility and Control:

- Question:** My IPv6 traffic is not being classified.

**Answer:** Currently only IPv4 traffic is supported.
- Question:** My multicast traffic is not being classified

**Answer:** Currently only unicast traffic is supported
- Question:** I send ping but I don't see them being classified

**Answer:** Only TCP/UDP protocols are supported
- Question:** Why can't I attach NBAR to an SVI?

**Answer:** NBAR is only supported on physical interfaces.
- Question:** I see that most of my traffic is CAPWAP traffic, why?

**Answer:** Make sure that you have enabled NBAR on an access port that is not connected to a wireless access port. All traffic coming from APs will be classified as capwap. Actual classification in this case happens either on the AP or WLC.
- Question:** In protocol-discovery, I see traffic only on one side. Along with that, there are a lot of unknown traffic.

**Answer:** This usually indicates that NBAR sees asymmetric traffic: one side of the traffic is classified in one switch member and the other on a different member. The recommendation is to attach NBAR only on access ports where we see both sides of the traffic. If you have multiple uplinks, you can't attach NBAR on them due to this issue. Similar issue happens if you configure NBAR on an interface that is part of a port channel.
- Question:** With protocol-discovery, I see an aggregate view of all application. How can I see traffic distribution over time?

**Answer:** WebUI will give you view of traffic over time for the last 48 hours.
- Question:** I can't configure queue-based egress policy with **match protocol protocol-name** command.

**Answer:** Only **shape** and **set DSCP** are supported in a policy with NBAR2 based classifiers. Common practice is to set DSCP on ingress and perform shaping on egress based on DSCP.

9. **Question:** I don't have NBAR2 attached to any interface but I still see that NBAR2 is activated.

**Answer:** If you have any class-map with **match protocol** *protocol-name*, NBAR will be globally activated on the stack but no traffic will be subjected to NBAR classification. This is an expected behavior and it does not consume any resources.

10. **Question:** I see some traffic under the default QoS queue. Why?

**Answer:** For each new flow, it takes a few packets to classify it and install the result in the hardware. During this time, the classification would be 'unknown' and traffic will fall under the default queue.

## Additional References for Application Visibility and Control

### Related Documents

| Related Topic                       | Document Title                                             |
|-------------------------------------|------------------------------------------------------------|
| QoS                                 | <i>NBAR Configuration Guide, Cisco IOS XE Release 16.x</i> |
| NBAR2 Protocol Pack Hitless Upgrade | <i>NBAR Configuration Guide, Cisco IOS XE Release 16.x</i> |

### Technical Assistance

| Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Link                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p> | <a href="http://www.cisco.com/support">http://www.cisco.com/support</a> |

## Feature History and Information For Application Visibility and Control in a Wired Network

| Release                    | Feature Information                                                                                                                                                         |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cisco IOS XE Denali 16.3.2 | Wired AVC Flexible NetFlow (FNF) — The feature uses a flow record with an application name as the key, to provide client, server and application statistics, per interface. |
| Cisco IOS XE Denali 16.3.1 | This feature was introduced.                                                                                                                                                |



## CHAPTER 137

# Configuring Application Visibility and Control in a Wireless Network

---

Application Visibility and Control (AVC) is a solution for Cisco network devices that provides application-level classification, monitoring, and traffic control to improve business-critical application performance, facilitate capacity management and planning, and reduce network operating costs. The Cisco AVC solution is provided within the Branch and Aggregation routers, Cisco Switches, and Cisco Wireless Controllers and Access points.

For information about AVC on Cisco Switches, see *Configuring Application Visibility and Control in a Wired Network*.

For information about AVC on Cisco Wireless Controllers and Access points, see *Configuring Application Visibility and Control in a Wireless Network*.

- [Finding Feature Information, on page 2533](#)
- [Information About Application Visibility and Control, on page 2534](#)
- [Supported AVC Class Map and Policy Map Formats, on page 2535](#)
- [Prerequisites for Application Visibility and Control, on page 2537](#)
- [Guidelines for Inter-Device Roaming with Application Visibility and Control, on page 2537](#)
- [Restrictions for Application Visibility and Control, on page 2537](#)
- [How to Configure Application Visibility and Control, on page 2539](#)
- [Monitoring Application Visibility and Control, on page 2555](#)
- [Examples: Application Visibility and Control, on page 2556](#)
- [Additional References for Application Visibility and Control, on page 2559](#)
- [Feature History and Information For Application Visibility and Control, on page 2560](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

# Information About Application Visibility and Control

Application Visibility and Control (AVC) classifies applications using deep packet inspection techniques with the Network-Based Application Recognition engine, and provides application-level visibility and control (QoS) in wireless networks. After the applications are recognized, the AVC feature enables you to either drop, mark, or police the data traffic.

AVC is configured by defining a class map in a QoS client policy to match a protocol.

Using AVC, we can detect more than 1000 applications. AVC enables you to perform real-time analysis and create policies to reduce network congestion, costly network link usage, and infrastructure upgrades.



**Note** You can view list of 30 applications in Top Applications in Monitor Summary section of the UI.

Traffic flows are analyzed and recognized using the NBAR2 engine at the access point. For more information about the NBAR2 Protocol Library, see [http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/qos\\_nbar/prot\\_lib/config\\_library/nbar-prot-pack-library.html](http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/qos_nbar/prot_lib/config_library/nbar-prot-pack-library.html). The specific flow is marked with the recognized protocol or application, such as WebEx. This per-flow information can be used for application visibility using Flexible NetFlow (FNF).

AVC QoS actions are applied with AVC filters in both upstream and downstream directions. The QoS actions supported for upstream flow are drop, mark, and police, and for downstream flow are mark and police. AVC QoS is applicable only when the application is classified correctly and matched with the class map filter in the policy map. For example, if the policy has a filter based on an application name, and the traffic has also been classified to the same application name, then the action specified for this match in the policy will be applied.



**Note** When you downgrade the controller from 8.0 to any earlier version, the AVC rate limit rules display the action as drop. This action is expected since the AVC rate limit rule is introduced in the controller version 8.0.

| Cisco WLC Platform | Flow    |
|--------------------|---------|
| Cisco 2504 WLC     | 26,250  |
| Cisco 5508 WLC     | 183,750 |
| Cisco WiSM2        | 393,750 |
| Cisco 8510 WLC     | 336,000 |
| Cisco 5520 WLC     | 336,000 |
| Cisco 8540 WLC     | 336,000 |

## Application Visibility and Control Protocol Packs

Protocol packs are a means to distribute protocol updates outside the switch software release trains, and can be loaded on the switch without replacing the switch software.

The Application Visibility and Control Protocol Pack (AVC Protocol Pack) is a single compressed file that contains multiple Protocol Description Language (PDL) files and a manifest file. A set of required protocols can be loaded, which helps AVC to recognize additional protocols for classification on your network. The manifest file gives information about the protocol pack, such as the protocol pack name, version, and some information about the available PDLs in the protocol pack.

The AVC Protocol Packs are released to specific AVC engine versions. You can load a protocol pack if the engine version on the switch platform is the same or higher than the version required by the protocol pack.

## Supported AVC Class Map and Policy Map Formats

### Supported AVC Class Map Format

| Class Map Format                                                                | Class Map Example                                                                                                                          | Direction                    |
|---------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| <b>match protocol</b> <i>protocol name</i>                                      | <code>class-map match-any<br/>webex-class<br/>match protocol webex-media</code>                                                            | Both upstream and downstream |
| <b>match protocol attribute category</b> <i>category-name</i>                   | <code>class-map match-any IM<br/>match protocol attribute<br/>category instant-messaging</code>                                            | Both upstream and downstream |
| <b>match protocol attribute sub-category</b> <i>sub-category-name</i>           | <code>class-map match-any<br/>realtimeconferencing<br/>match protocol attribute<br/>sub-category<br/>voice-video-chat-collaboration</code> | Both upstream and downstream |
| <b>match protocol attribute application-group</b> <i>application-group-name</i> | <code>class-map match-any skype<br/>match protocol attribute<br/>application-group skype-group</code>                                      | Both upstream and downstream |
| Combination filters                                                             | <code>class-map match-any<br/>webex-class<br/>match protocol webex<br/>match dscp 45<br/>match wlan user-priority 6</code>                 | Upstream only                |

### Supported AVC Policy Format

| Policy Format                                           | QoS Action             |
|---------------------------------------------------------|------------------------|
| Upstream client policy based on match protocol filter   | Mark, police, and drop |
| Downstream client policy based on match protocol filter | Mark and police        |

The following table describes the detailed AVC policy format with an example:

| AVC Policy Format                         | AVC Policy Example                                                                                                                                                                                                                                             | Direction               |
|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| Basic set                                 | <pre>policy-map webex-policy class webex-class set dscp ef //or set up,cos</pre>                                                                                                                                                                               | Upstream and downstream |
| Basic police                              | <pre>policy-map webex-policy class webex-class police 5000000</pre>                                                                                                                                                                                            | Upstream and downstream |
| Basic set and police                      | <pre>policy-map webex-policy class webex-class set dscp ef //or set up,cos police 5000000</pre>                                                                                                                                                                | Upstream and downstream |
| Multiple set and police including default | <pre>policy-map webex-policy class webex-class set dscp af31 //or set up,cos  police 4000000 class class-webex-category set dscp ef //or set up,cos police 6000000 class class-default set dscp &lt;&gt;</pre>                                                 | Upstream and downstream |
| Hierarchical police                       | <pre>policy-map webex-policy class webex-class police 5000000 service-policy client-in-police-only  policy-map client-in-police-only class webex-class police 100000 class class-webex-category set dscp ef //or set up,cos police 6000000 police 200000</pre> | Upstream and downstream |
| Hierarchical set and police               | <pre>policy-map webex-policy class class-default police 1500000 service policy client-up-child policy-map webex-policy class webex-class police 100000 set dscp ef class class-webex-category police 200000 set dscp af31</pre>                                |                         |

| AVC Policy Format | AVC Policy Example                                                                                                                                                                                                                             | Direction     |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Drop action       | <p>Any of the above examples apply to this format with this additional example:</p> <pre> policy-map webex-policy class webex-class drop class netflix set dscp ef //or set up,cos police 6000000 class class-default set dscp &lt;&gt; </pre> | Upstream only |

## Prerequisites for Application Visibility and Control

- The access points should be AVC capable.
- For the control part of AVC (QoS) to work, the application visibility feature with FNF has to be configured.

## Guidelines for Inter-Device Roaming with Application Visibility and Control

Follow these guidelines to prevent clients from getting excluded due to malformed QoS policies:

- When a new QoS policy is added to the device, a QoS policy with the same name should be added to other device within the same roam or mobility domain.
- When a device is loaded with a software image of a later release, the new policy formats are supported. If you have upgraded the software image from an earlier release to a later release, you should save the configuration separately. When an earlier release image is loaded, some QoS policies might show as not supported, and you should restore those QoS policies to supported policy formats.

## Restrictions for Application Visibility and Control

- AVC is supported only on the following access points:
  - Cisco Aironet 1260 Series Access Points
  - Cisco Aironet 1600 Series Access Points
  - Cisco Aironet 2600 Series Access Point
  - Cisco Aironet 2600 Series Wireless Access Points
  - Cisco Aironet 2700 Series Access Point
  - Cisco Aironet 3500 Series Access Points

- Cisco Aironet 3600 Series Access Points
- AVC is not supported on Cisco Aironet 702W, 702I (128 M memory), and 1530 Series Access Points.
- Dropping or marking of the data traffic (control part) is not supported for software Release 3.3.
- Dropping or marking of the data traffic (control part) is supported in software Release 3E.
- Only the applications that are recognized with application visibility can be used for applying QoS control.
- Multicast traffic classification is not supported.
- Only the applications that are recognized with App visibility can be used for applying QoS control.
- IPv6 including ICMPv6 traffic classifications are not supported.
- Datalink is not supported for NetFlow fields for AVC.
- The following commands are not supported for AVC flow records:
  - **collect flow username**
  - **collect interface { input | output }**
  - **collect wireless client ipv4 address**
  - **match interface { input | output }**
  - **match transport igmp type**
- The template timeout cannot be modified on exporters configured with AVC. Even if the template timeout value is configured to a different value, only the default value of 600 seconds is used.
- For the username information in the AVC-based record templates, ensure that you configure the options **records** to get the user MAC address to username mapping.
- When there is a mix of AVC-enabled APs such as 3600, and non-AVC-enabled APs such as 1140, and the chosen policy for the client is AVC-enabled, the policy will not be sent to the APs that cannot support AVC.
- Only ingress AVC statistics are supported. The frequency of statistics updates depends on the number of clients loaded at the AP at that time. Statistics are not supported for very large policy format sizes.
- The total number of flows for which downstream AVC QoS supported per client is 1000.
- The maximum number of flows supported for Catalyst 3850 Series Switch is 48 K.
- These are some class map and policy map-related restrictions. For supported policy formats, see [Supported AVC Class Map and Policy Map Formats, on page 2535](#)
  - AVC and non-AVC classes cannot be defined together in a policy in a downstream direction. For example, when you have a class map with match protocol, you cannot use any other type of match filter in the policy map in the downstream direction.
  - Drop action is not applicable for the downstream AVC QoS policy.
  - Match protocol is not supported in ingress or egress for SSID policy.



- Google shares resources among several of their services because of which for some of the traffic it is not possible to say it is unique to one application. Therefore we added google-services for traffic that cannot be distinguished. The behavior you experience is expected.
- AVC is not supported on management port (Gig 0/0).
- NBAR based QoS policy configuration is allowed only on wired physical ports. Policy configuration is not supported on virtual interfaces, for example, VLAN, Port-Channel and other logical interfaces.
- NBAR and NetFlow cannot be configured together at the same time on the same interface.

## How to Configure Application Visibility and Control

### Configuring Application Visibility and Control (CLI)

To configure Application Visibility, follow these general steps:

1. Create a flow record by specifying keys and non-key fields to the flow.
2. Create an optional flow exporter by specifying the flow record as an option.
3. Create a flow monitor based on the flow record and flow exporter.
4. Configure WLAN to apply flow monitor in IPv4 input or output direction.

To configure Application Control, follow these general steps:

1. Create an AVC QoS policy.
2. Attach AVC QoS policy to the client in one of three ways: configuring WLAN, using ACS or ISE, or adding local policies.

To enable application recognition on an interface, see [Enabling Application Recognition on an interface](#).

### Creating a Flow Record

By default, **wireless avc basic** (flow record) is available. When you click **Apply** from the GUI, then the record is mapped to the flow monitor.

Default flow record cannot be edited or deleted. If you require a new flow record, you need to create one and map it to the flow monitor from CLI.

#### Procedure

|               | Command or Action                                                                                                                                | Purpose                                |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                            | Enters global configuration mode.      |
| <b>Step 2</b> | <b>flow record <i>flow_record_name</i></b><br><br><b>Example:</b><br>Device (config)# <b>flow record record1</b><br>Device (config-flow-record)# | Enters flow record configuration mode. |

|                | Command or Action                                                                                                                             | Purpose                                                                                                                                                            |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 3</b>  | <b>description</b> <i>string</i><br><b>Example:</b><br>Device (config-flow-record) # <b>description</b><br><b>IPv4flow</b>                    | (Optional) Describes the flow record as a maximum 63-character string.                                                                                             |
| <b>Step 4</b>  | <b>match ipv4 protocol</b><br><b>Example:</b><br>Device (config-flow-record) # <b>match ipv4</b><br><b>protocol</b>                           | Specifies a match to the IPv4 protocol.                                                                                                                            |
| <b>Step 5</b>  | <b>match ipv4 source address</b><br><b>Example:</b><br>Device (config-flow-record) # <b>match ipv4</b><br><b>source address</b>               | Specifies a match to the IPv4 source address-based field.                                                                                                          |
| <b>Step 6</b>  | <b>match ipv4 destination address</b><br><b>Example:</b><br>Device (config-flow-record) # <b>match ipv4</b><br><b>destination address</b>     | Specifies a match to the IPv4 destination address-based field.                                                                                                     |
| <b>Step 7</b>  | <b>match transport source-port</b><br><b>Example:</b><br>Device (config-flow-record) # <b>match</b><br><b>transport source-port</b>           | Specifies a match to the transport layer source-port field.                                                                                                        |
| <b>Step 8</b>  | <b>match transport destination-port</b><br><b>Example:</b><br>Device (config-flow-record) # <b>match</b><br><b>transport destination-port</b> | Specifies a match to the transport layer destination-port field.                                                                                                   |
| <b>Step 9</b>  | <b>match flow direction</b><br><b>Example:</b><br>Device (config-flow-record) # <b>match flow</b><br><b>direction</b>                         | Specifies a match to the direction the flow was monitored in.                                                                                                      |
| <b>Step 10</b> | <b>match application name</b><br><b>Example:</b><br>Device (config-flow-record) # <b>match</b><br><b>application name</b>                     | Specifies a match to the application name.<br><b>Note</b> This action is mandatory for AVC support, as this allows the flow to be matched against the application. |
| <b>Step 11</b> | <b>match wireless ssid</b><br><b>Example:</b><br>Device (config-flow-record) # <b>match</b><br><b>wireless ssid</b>                           | Specifies a match to the SSID name identifying the wireless network.                                                                                               |

|                | Command or Action                                                                                                                        | Purpose                                                                                                                                                                            |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 12</b> | <b>collect counter bytes long</b><br><b>Example:</b><br>Device (config-flow-record)# <b>collect counter bytes long</b>                   | Specifies to collect counter fields total bytes.                                                                                                                                   |
| <b>Step 13</b> | <b>collect counter packets long</b><br><b>Example:</b><br>Device (config-flow-record)# <b>collect counter bytes long</b>                 | Specifies to collect counter fields total packets.                                                                                                                                 |
| <b>Step 14</b> | <b>collect wireless ap mac address</b><br><b>Example:</b><br>Device (config-flow-record)# <b>collect wireless ap mac address</b>         | Specifies to collect the BSSID with MAC addresses of the access points that the wireless client is associated with.                                                                |
| <b>Step 15</b> | <b>collect wireless client mac address</b><br><b>Example:</b><br>Device (config-flow-record)# <b>collect wireless client mac address</b> | Specifies to collect MAC address of the client on the wireless network.<br><b>Note</b> The <b>collect wireless client mac address</b> is mandatory configuration for wireless AVC. |
| <b>Step 16</b> | <b>end</b><br><b>Example:</b><br>Device (config)# <b>end</b>                                                                             | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                |

## Creating a Flow Exporter (Optional)

You can create a flow export to define the export parameters for a flow. This is an optional procedure for configuring flow parameters.

### Procedure

|               | Command or Action                                                                                                                                    | Purpose                                                     |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                                    | Enters global configuration mode.                           |
| <b>Step 2</b> | <b>flow exporter <i>flow_exporter_name</i></b><br><b>Example:</b><br>Device (config)# <b>flow exporter record1</b><br>Device (config-flow-exporter)# | Enters flow exporter configuration mode.                    |
| <b>Step 3</b> | <b>description <i>string</i></b><br><b>Example:</b>                                                                                                  | Describes the flow record as a maximum 63-character string. |

|                | Command or Action                                                                                                                                                             | Purpose                                                                                                             |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
|                | Device (config-flow-exporter) #<br><b>description IPv4flow</b>                                                                                                                |                                                                                                                     |
| <b>Step 4</b>  | <b>destination</b> {hostname   ip-address}<br><br><b>Example:</b><br>Device (config-flow-exporter) #<br><b>destination 10.99.1.4</b>                                          | Specifies the hostname or IPv4 address of the system to which the exporter sends data.                              |
| <b>Step 5</b>  | <b>transport udp</b> port-value<br><br><b>Example:</b><br>Device (config-flow-exporter) #<br><b>transport udp 2</b>                                                           | Configures a port value for the UDP protocol.                                                                       |
| <b>Step 6</b>  | <b>option application-table timeout</b> seconds<br>(optional)<br><br><b>Example:</b><br>Device (config-flow-exporter) # <b>option</b><br><b>application-table timeout 500</b> | (Optional) Specifies application table timeout option. The valid range is from 1 to 86400 seconds.                  |
| <b>Step 7</b>  | <b>option usermac-table timeout</b> seconds<br>(optional)<br><br><b>Example:</b><br>Device (config-flow-exporter) # <b>option</b><br><b>usermac-table timeout 1000</b>        | (Optional) Specifies wireless usermac-to-username table option. The valid range is from 1 to 86400 seconds.         |
| <b>Step 8</b>  | <b>end</b><br><br><b>Example:</b><br>Device (config) # <b>end</b>                                                                                                             | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |
| <b>Step 9</b>  | <b>show flow exporter</b><br><br><b>Example:</b><br>Device # <b>show flow exporter</b>                                                                                        | Verifies your configuration.                                                                                        |
| <b>Step 10</b> | <b>end</b><br><br><b>Example:</b><br>Device (config) # <b>end</b>                                                                                                             | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

## Creating a Flow Monitor

You can create a flow monitor and associate it with a flow record and a flow exporter.

### Procedure

|               | Command or Action                                | Purpose                           |
|---------------|--------------------------------------------------|-----------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><br><b>Example:</b> | Enters global configuration mode. |

|               | Command or Action                                                                                                                                                                                                                                            | Purpose                                                                                                                                                                                                                                                                                   |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | Device# <b>configure terminal</b>                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                           |
| <b>Step 2</b> | <b>flow monitor</b> <i>monitor-name</i><br><b>Example:</b><br>Device (config)# <b>flow monitor</b><br>flow-monitor-1                                                                                                                                         | Creates a flow monitor and enters flow monitor configuration mode.                                                                                                                                                                                                                        |
| <b>Step 3</b> | <b>description</b> <i>description</i><br><b>Example:</b><br>Device (config-flow-monitor)# <b>description</b><br>flow-monitor-1                                                                                                                               | Creates a description for the flow monitor.                                                                                                                                                                                                                                               |
| <b>Step 4</b> | <b>record</b> <i>record-name</i><br><b>Example:</b><br>Device (config-flow-monitor)# <b>record</b><br>flow-record-1                                                                                                                                          | Specifies the name of a recorder that was created previously.                                                                                                                                                                                                                             |
| <b>Step 5</b> | <b>exporter</b> <i>exporter-name</i><br><b>Example:</b><br>Device (config-flow-monitor)# <b>exporter</b><br>flow-exporter-1                                                                                                                                  | Specifies the name of an exporter that was created previously.                                                                                                                                                                                                                            |
| <b>Step 6</b> | <b>cache timeout</b> { <b>active</b>   <b>inactive</b> } ( <b>Optional</b> )<br><b>Example:</b><br>Device (config-flow-monitor)# <b>cache</b><br><b>timeout active 1800</b><br><br>Device (config-flow-monitor)# <b>cache</b><br><b>timeout inactive 200</b> | Specifies to configure flow cache parameters. You can configure for a time period of 1 to 604800 seconds (optional).<br><br><b>Note</b> To achieve optimal result for the AVC flow monitor, we recommend you to configure the inactive cache timeout value to be greater than 90 seconds. |
| <b>Step 7</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b>                                                                                                                                                                                                  | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                                                                                                                       |
| <b>Step 8</b> | <b>show flow monitor</b><br><b>Example:</b><br>Device # <b>show flow monitor</b>                                                                                                                                                                             | Verifies your configuration.                                                                                                                                                                                                                                                              |

## Creating AVC QoS Policy

To create AVC QoS policy, perform these general steps:

1. Create a class map with match protocol filters.
2. Create a policy map.
3. Apply a policy map to the client in one of the following ways:

- a. Apply a policy map over WLAN either from the CLI or GUI.
- b. Apply a policy map through the AAA server (ACS server or ISE) from the CLI.

For more information, refer to the *Cisco Identity Services Engine User Guide* and *Cisco Secure Access Control System User Guide*.

- c. Apply local policies either from the CLI or GUI.

## Creating a Class Map

You need to create a class map before configuring any match protocol filter. The QoS actions such as marking, policing, and dropping can be applied to the traffic. The AVC match protocol filters are applied only for the wireless clients. For more information about the protocols that are supported, see [http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/qos\\_nbar/prot\\_lib/config\\_library/nbar-prot-pack-library.html](http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/qos_nbar/prot_lib/config_library/nbar-prot-pack-library.html).

### Procedure

|               | Command or Action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Purpose                                                                                         |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Enters global configuration mode.                                                               |
| <b>Step 2</b> | <b>class-map class-map-name</b><br><b>Example:</b><br>Device(config)# <b>class-map webex-class</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Creates a class map.                                                                            |
| <b>Step 3</b> | <b>match protocol {application-name   attribute category category-name   attribute sub-category sub-category-name   attribute application-group application-group-name }</b><br><b>Example:</b><br>Device(config)# <b>class-map webex-class</b><br>Device(config-cmap)# <b>match protocol webex-media</b><br><br>Device(config)# <b>class-map class-webex-category</b><br>Device(config-cmap)# <b>match protocol attribute category webex-media</b><br><br>Device# <b>class-map class-webex-sub-category</b><br>Device(config-cmap)# <b>match protocol attribute sub-category webex-media</b><br><br>Device# <b>class-map class-webex-application-group</b><br>Device(config-cmap)# <b>match protocol attribute application-group webex-media</b> | Specifies match to the application name, category name, subcategory name, or application group. |

|               | Command or Action                                            | Purpose                                                                                                             |
|---------------|--------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| <b>Step 4</b> | <b>end</b><br><b>Example:</b><br>Device(config) # <b>end</b> | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

## Creating a Policy Map

### Procedure

|               | Command or Action                                                                                                                                               | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                                               | Enters global configuration mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Step 2</b> | <b>policy-map <i>policy-map-name</i></b><br><b>Example:</b><br>Device(config) # <b>policy-map webex-policy</b><br>Device(config-pmap) #                         | <p>Creates a policy map by entering the policy map name, and enters policy-map configuration mode.</p> <p>By default, no policy maps are defined.</p> <p>The default behavior of a policy map is to set the DSCP to 0 if the packet is an IP packet and to set the CoS to 0 if the packet is tagged. No policing is performed.</p> <p><b>Note</b> To delete an existing policy map, use the <b>no policy-map <i>policy-map-name</i></b> global configuration command.</p>                                                                                                                                                                                                                                                                                                                           |
| <b>Step 3</b> | <b>class [<i>class-map-name</i>   <b>class-default</b>]</b><br><b>Example:</b><br>Device(config-pmap) # <b>class-map webex-class</b><br>Device(config-pmap-c) # | <p>Defines a traffic classification, and enters policy-map class configuration mode.</p> <p>By default, no policy map and class maps are defined.</p> <p>If a traffic class has already been defined by using the <b>class-map</b> global configuration command, specify its name for <i>class-map-name</i> in this command.</p> <p>A <b>class-default</b> traffic class is predefined and can be added to any policy. It is always placed at the end of a policy map. With an implied <b>match any</b> is included in the <b>class-default</b> class, all packets that have not already matched the other traffic classes will match <b>class-default</b>.</p> <p><b>Note</b> To delete an existing class map, use the <b>no class <i>class-map-name</i></b> policy-map configuration command.</p> |

|               | Command or Action                                                                                                                                                                                     | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 4</b> | <p><b>police</b> <i>rate-bps burst-byte</i> [<b>exceed-action</b> {<b>drop</b>   <b>policed-dscp-transmit</b>}]</p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# police 100000 80000 drop</pre> | <p>Defines a policer for the classified traffic.</p> <p>By default, no policer is defined.</p> <ul style="list-style-type: none"> <li>For <i>rate-bps</i>, specify an average traffic rate in bits per second (b/s). The range is 8000 to 10000000000.</li> <li>For <i>burst-byte</i>, specify the normal burst size in bytes. The range is 8000 to 1000000.</li> <li>(Optional) Specifies the action to take when the rates are exceeded. Use the <b>exceed-action drop</b> keywords to drop the packet. Use the <b>exceed-action policed-dscp-transmit</b> keywords to mark down the DSCP value (by using the policed-DSCP map) and to send the packet.</li> </ul> |
| <b>Step 5</b> | <p><b>set</b> {<b>dscp</b> <i>new-dscp</i>   <b>cos</b> <i>cos-value</i>}</p> <p><b>Example:</b></p> <pre>Device(config-pmap-c)# set dscp 45</pre>                                                    | <p>Classifies IP traffic by setting a new value in the packet.</p> <ul style="list-style-type: none"> <li>For <b>dscp</b> <i>new-dscp</i>, enter a new DSCP value to be assigned to the classified traffic. The range is 0 to 63.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Step 6</b> | <p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>                                                                                                                               | <p>Returns to privileged EXEC mode.</p> <p>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

### What to do next

After creating your policy maps, attach the traffic policy or policies to an interface using the **service-policy** command.

## Configuring Local Policies (CLI)

### Configuring Local Policies (CLI)

To configure local policies, complete these procedures:

1. Create a service template.
2. Create an interface template.
3. Create a parameter map.
4. Create a policy map.
5. Apply a local policy on a WLAN.



## Creating a Service Template (CLI)

## Procedure

|               | Command or Action                                                                                                                                                                     | Purpose                                                                                                             |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                                                                     | Enters global configuration mode.                                                                                   |
| <b>Step 2</b> | <b>service-template <i>service-template-name</i></b><br><b>Example:</b><br>Device(config)# <b>service-template</b><br><b>cisco-phone-template</b><br>Device(config-service-template)# | Enters service template configuration mode.                                                                         |
| <b>Step 3</b> | <b>access-group <i>acl_list</i></b><br><b>Example:</b><br>Device(config-service-template)#<br><b>access-group foo-acl</b>                                                             | Specifies the access list to be applied.                                                                            |
| <b>Step 4</b> | <b>vlan <i>vlan_id</i></b><br><b>Example:</b><br>Device(config-service-template)# <b>vlan</b><br><b>100</b>                                                                           | Specifies VLAN ID. You can specify a value from 1 to 4094.                                                          |
| <b>Step 5</b> | <b>absolute-timer <i>seconds</i></b><br><b>Example:</b><br>Device(config-service-template)#<br><b>absolute-timer 20</b>                                                               | Specifies session timeout value for service template. You can specify a value from 1 to 65535.                      |
| <b>Step 6</b> | <b>service-policy qos {input   output}</b><br><b>Example:</b><br>Device(config-service-template)#<br><b>service-policy qos input foo-qos</b>                                          | Configures QoS policies for the client.                                                                             |
| <b>Step 7</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b>                                                                                                                           | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

## Creating a Parameter Map (CLI)

Parameter map is preferred to use than class map.

## Procedure

|               | Command or Action                                                                                                                                                                                                                                                                                                            | Purpose                                                                                                                |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                                                                                                                                                                                                            | Enters global configuration mode.                                                                                      |
| <b>Step 2</b> | <b>parameter-map type subscriber</b><br><b>attribute-to-service</b> <i>parameter-map-name</i><br><b>Example:</b><br>Device(config)# <b>parameter-map type</b><br><b>subscriber attribute-to-service</b><br><b>Aironet-Policy-para</b>                                                                                        | Specifies the parameter map type and name.                                                                             |
| <b>Step 3</b> | <b>map-index map</b> { <b>device-type</b>   <b>mac-address</b><br>  <b>oui</b>   <b>user-role</b>   <b>username</b> } { <b>eq</b>   <b>not-eq</b><br>  <b>regex</b> <i>filter-name</i> }<br><b>Example:</b><br>Device(config-parameter-map-filter)# <b>10</b><br><b>map device-type eq</b><br><b>"WindowsXP-Workstation"</b> | Specifies parameter map attribute filter criteria.                                                                     |
| <b>Step 4</b> | <b>interface-template</b> <i>interface-template-name</i><br><b>Example:</b><br>Device(config-parameter-map-filter-submode)#<br><b>interface-template cisco-phone-template</b><br>Device(config-parameter-map-filter-submode)#                                                                                                | Enters service template configuration mode.                                                                            |
| <b>Step 5</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b>                                                                                                                                                                                                                                                                  | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

## Creating a Policy Map (CLI)

## Procedure

|               | Command or Action                                                                      | Purpose                           |
|---------------|----------------------------------------------------------------------------------------|-----------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>      | Enters global configuration mode. |
| <b>Step 2</b> | <b>policy-map type control subscriber</b><br><i>policy-map-name</i><br><b>Example:</b> | Specifies the policy map type.    |

|               | Command or Action                                                                                                                                                                                                                                                                     | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | <pre>Device(config)# policy-map type control subscriber Aironet-Policy</pre>                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Step 3</b> | <p><b>event identity-update</b> { <b>match-all</b>   <b>match-first</b> }</p> <p><b>Example:</b></p> <pre>Device(config-policy-map)# event identity-update match-all</pre>                                                                                                            | Specifies match criteria to the policy map.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Step 4</b> | <p><b>class</b> <i>number</i> <b>class</b> { <i>class_map_name</i>   <b>always</b> } { <b>do-all</b>   <b>do-until-failure</b>   <b>do-until-success</b> }</p> <p><b>Example:</b></p> <pre>Device(config-class-control-policymap)# 1 class local_policy1_class do-until-success</pre> | <p>Configures the local profiling policy class map number and specifies how to perform the action. The class map configuration mode includes the following command options:</p> <ul style="list-style-type: none"> <li>• <b>always</b>—Executes without doing any matching but return success.</li> <li>• <b>do-all</b>—Executes all the actions.</li> <li>• <b>do-until-failure</b>—Execute all the actions until any match failure is encountered. This is the default value.</li> <li>• <b>do-until-success</b>—Execute all the actions until any match success happens.</li> </ul> |
| <b>Step 5</b> | <p><b>action-index map</b> <i>attribute-to-service table</i> <i>parameter-map-name</i></p> <p><b>Example:</b></p> <pre>Device(config-policy-map)# 10 map attribute-to-service table Aironet-Policy-para</pre>                                                                         | Specifies parameter map table to be used.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Step 6</b> | <p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>                                                                                                                                                                                                               | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

### Applying a Local Policy for a Device on a WLAN (CLI)

#### Before you begin

If the service policy contains any device type-based rules in the parameter map, ensure that the device classifier is already enabled.



**Note** You should use the **device classification** command to classify the device for it to be displayed correctly on the show command output.

## Procedure

|               | Command or Action                                                                                                                                                             | Purpose                                                                                                             |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                                                             | Enters global configuration mode.                                                                                   |
| <b>Step 2</b> | <b>wlan wlan-name</b><br><b>Example:</b><br>Device(config)# <b>wlan wlan1</b>                                                                                                 | Enters WLAN configuration mode.                                                                                     |
| <b>Step 3</b> | <b>service-policy type control subscriber</b><br><i>polycymapname</i><br><b>Example:</b><br>Device(config-wlan)# <b>service-policy type control subscriber Aironet-Policy</b> | Applies local policy to WLAN.                                                                                       |
| <b>Step 4</b> | <b>profiling local http (optional)</b><br><b>Example:</b><br>Device(config-wlan)# <b>profiling local http</b>                                                                 | Enables only profiling of devices based on HTTP protocol (optional).                                                |
| <b>Step 5</b> | <b>profiling radius http (optional)</b><br><b>Example:</b><br>Device(config-wlan)# <b>profiling radius http</b>                                                               | Enables profiling of devices on ISE (optional).                                                                     |
| <b>Step 6</b> | <b>no shutdown</b><br><b>Example:</b><br>Device(config-wlan)# <b>no shutdown</b>                                                                                              | Specifies not to shut down the WLAN.                                                                                |
| <b>Step 7</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b>                                                                                                                   | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

## Configuring WLAN to Apply Flow Monitor in IPV4 Input/Output Direction

## Procedure

|               | Command or Action                                                                 | Purpose                           |
|---------------|-----------------------------------------------------------------------------------|-----------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b> | Enters global configuration mode. |

|               | Command or Action                                                                                                                                                  | Purpose                                                                                                             |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| <b>Step 2</b> | <b>wlan</b> <i>wlan-id</i><br><b>Example:</b><br><br>Device (config) # <b>wlan</b> 1                                                                               | Enters WLAN configuration submode. For <i>wlan-id</i> , enter the WLAN ID. The range is 1 to 64.                    |
| <b>Step 3</b> | <b>ip flow monitor</b> <i>monitor-name</i> {input   output}<br><b>Example:</b><br><br>Device (config-wlan) # <b>ip flow monitor</b><br><b>flow-monitor-1 input</b> | Associates a flow monitor to the WLAN for input or output packets.                                                  |
| <b>Step 4</b> | <b>end</b><br><b>Example:</b><br><br>Device (config) # <b>end</b>                                                                                                  | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

## AP Downstream QoS

### Information About AP downstream QoS

AP downstream QoS is the process of marking traffic from the controller to the AP. This is achieved by using the flow information from AP on the downstream traffic.

Polaris-based controllers do not support NBAR and the NBAR resides in the AP. When an AP is connected to the WLC (in local-mode with AVC-enabled) the AP performs the application visibility in the upstream and helps the controller to classify traffic (AP assist) in the downstream direction.

In the upstream direction, the control of the classified applications is done by the AP. In the downstream direction, after inspecting the first packet from the WLC, the AP informs the controller about the traffic session and the controller marks the traffic accordingly.



**Note** AP assist is done only for application based marking.

### Configuring Class-map for Downstream QoS

Follow the procedure given below to configure class-map for downstream QoS:

#### Procedure

|               | Command or Action                                                                     | Purpose                           |
|---------------|---------------------------------------------------------------------------------------|-----------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br><br>Device# <b>configure terminal</b> | Enters global configuration mode. |

|               | Command or Action                                                                                                    | Purpose                                                  |
|---------------|----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| <b>Step 2</b> | <b>class-map match-any</b> <i>class-map-name</i><br><b>Example:</b><br>Device(config)# class-map match-any<br>class1 | Configures a matching class-name under this classmap.    |
| <b>Step 3</b> | <b>match protocol ftp</b><br><b>Example:</b><br>Device(config-cmap)# match protocol ftp                              | Configures FTP as the match protocol.                    |
| <b>Step 4</b> | <b>match protocol ftp-data</b><br><b>Example:</b><br>Device(config-cmap)# match protocol<br>ftp-data                 | Configures FTP as the match protocol for data part only. |

## Configuring Policy with Policing for Downstream QoS

Follow the procedure given below to configure policing for downstream QoS:

### Procedure

|               | Command or Action                                                                                                                      | Purpose                                                                          |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# configure terminal                                                             | Enters global configuration mode.                                                |
| <b>Step 2</b> | <b>policy-map</b> <i>policy-map-name</i><br><b>Example:</b><br>Device(config)# policy-map policy1                                      | Creates a policy map by entering the policy map name.                            |
| <b>Step 3</b> | <b>class</b> <i>class-map-name</i><br><b>Example:</b><br>Device(config-pmap)#class class1                                              | Specifies the name of the class whose policy you want to create.                 |
| <b>Step 4</b> | <b>police cir</b> <i>bit-rate</i> <b>bc</b> <i>burst-rate</i><br><b>Example:</b><br>Device(config-pmap-c)# police cir 10000<br>bc 1500 | Configures the policer with committed information rate bit rate and burst rates. |
| <b>Step 5</b> | <b>conform-action transmit</b><br><b>Example:</b><br>Device(config-pmap-c-police)#<br>conform-action transmit                          | Transmits all the packets.                                                       |
| <b>Step 6</b> | <b>exceed-action drop</b><br><b>Example:</b>                                                                                           | Drops all the packets.                                                           |

|  | Command or Action                                  | Purpose |
|--|----------------------------------------------------|---------|
|  | Device(config-pmap-c-poice)#<br>exceed-action drop |         |

## Configuring Policy-map for Downstream QoS (set-dscp)

Follow the procedure given below to configure policy-map for downstream QoS (set-dscp):

### Procedure

|               | Command or Action                                                                                     | Purpose                                                          |
|---------------|-------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><br><b>Example:</b><br>Device# configure terminal                        | Enters global configuration mode.                                |
| <b>Step 2</b> | <b>policy-map <i>policy-map-name</i></b><br><br><b>Example:</b><br>Device(config)# policy-map policy1 | Configures a matching policy-name under this policymap.          |
| <b>Step 3</b> | <b>class <i>class-map-name</i></b><br><br><b>Example:</b><br>Device(config-pmap)#class class1         | Specifies the name of the class whose policy you want to create. |
| <b>Step 4</b> | <b>set dscp</b><br><br><b>Example:</b><br>Device(config-pmap-c)# set dscp af41                        | Matches packets with AF41 dscp .                                 |

## Configuring Policy-map for Downstream QoS (drop)

Follow the procedure given below to configure policy-map for downstream QoS (drop):

### Procedure

|               | Command or Action                                                                                     | Purpose                                                          |
|---------------|-------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><br><b>Example:</b><br>Device# configure terminal                        | Enters global configuration mode.                                |
| <b>Step 2</b> | <b>policy-map <i>policy-map-name</i></b><br><br><b>Example:</b><br>Device(config)# policy-map policy1 | Configures a matching policy-name under this policymap.          |
| <b>Step 3</b> | <b>class <i>class-map-name</i></b><br><br><b>Example:</b><br>Device(config-pmap)#class class1         | Specifies the name of the class whose policy you want to create. |

|               | Command or Action                                             | Purpose                |
|---------------|---------------------------------------------------------------|------------------------|
| <b>Step 4</b> | <b>drop</b><br><b>Example:</b><br>Device(config-pmap-c)# drop | Drops all the packets. |

## Configuring Policy-map for Downstream QoS on the WLAN

Follow the procedure given below to configure policy-map for downstream QoS on the WLAN:

### Before you begin

The following options are not supported for match app in the downstream direction on the WLAN:

- set dscp
- drop
- policing

### Procedure

|               | Command or Action                                                                                                                 | Purpose                                                                                        |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# configure terminal                                                        | Enters global configuration mode.                                                              |
| <b>Step 2</b> | <b>wlan profile-name wlan-id ssid</b><br><b>Example:</b><br>Device(config)# wlan wlan11 11 test_p11                               | Configures the WLAN details.                                                                   |
| <b>Step 3</b> | <b>client vlan wlan-id</b><br><b>Example:</b><br>Device(config-wlan)# client vlan 1                                               | Maps the VLAN group to the WLAN by entering the VLAN identifier, VLAN group, or the VLAN name. |
| <b>Step 4</b> | <b>ip flow monitor flow-monitor input</b><br><b>Example:</b><br>Device(config-wlan)# ip flow monitor monitor1 input               | Assigns the flow monitor that is created to the ingress interface.                             |
| <b>Step 5</b> | <b>ip flow monitor flow-monitor output</b><br><b>Example:</b><br>Device(config-wlan)# ip flow monitor monitor1 output             | Assigns the flow monitor that is created to the egress interface.                              |
| <b>Step 6</b> | <b>service-policy client input policy-map-name</b><br><b>Example:</b><br>Device(config-wlan)# service-policy client input policy1 | Assigns policy-map to all clients in WLAN.                                                     |



|               | Command or Action                                                                                                   | Purpose                            |
|---------------|---------------------------------------------------------------------------------------------------------------------|------------------------------------|
| <b>Step 7</b> | <b>session-timeout</b> <i>session-duration</i><br><b>Example:</b><br>Device(config-wlan) # session-timeout<br>10000 | Sets the session timeout duration. |
| <b>Step 8</b> | <b>shutdown</b><br><b>Example:</b><br>Device(config-wlan) # shutdown                                                | Disables the WLAN.                 |

# Monitoring Application Visibility and Control

## Monitoring Application Visibility and Control (CLI)

This section describes the new commands for application visibility.

The following commands can be used to monitor application visibility on the and access points.

**Table 200: Monitoring Application Visibility Commands on the**

| Command                                                                                                                         | Purpose                                                                                                                                                                                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>show avc client</b> <i>client-mac</i> <b>top n application</b> [ <b>aggregate</b>   <b>upstream</b>   <b>downstream</b> ]    | Displays information about top "N" applications for the given client MAC.                                                                                                                                                                                                                                                                     |
| <b>show avc wlan</b> <i>ssid</i> <b>top n application</b> [ <b>aggregate</b>   <b>upstream</b>   <b>downstream</b> ]            | Displays information about top "N" applications for the given SSID.                                                                                                                                                                                                                                                                           |
| <b>avc top user</b> [ <b>enable</b>   <b>disable</b> ]                                                                          | Enables or disables the information about top "N" application.                                                                                                                                                                                                                                                                                |
| <b>show avc wlan</b> <i>wlan-id</i> <b>application app name topN</b> [ <b>aggregate</b>   <b>upstream</b>   <b>downstream</b> ] | Displays to know network usage information on a per user basis within an application.<br><br><b>Note</b> On Catalyst 4500E Supervisor Engine 8-E, in the information about top N users that is displayed, the client's MAC address and username are not displayed. This issue occurs only within 90 seconds after the client is disconnected. |
| <b>show wlan id</b> <i>wlan-id</i>                                                                                              | Displays information whether AVC is enabled or disabled on a particular WLAN.                                                                                                                                                                                                                                                                 |
| <b>show flow monitor</b> <i>flow_monitor_name</i> <b>cache</b>                                                                  | Displays information about flow monitors.                                                                                                                                                                                                                                                                                                     |
| <b>show wireless client mac-address</b> <i>mac-address</i> <b>service-policy</b> { <b>input</b>   <b>output</b> }               | Displays information about policy mapped to the wireless clients.                                                                                                                                                                                                                                                                             |

|                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <pre>show ip nbar protocol-discovery [interface interface-type interface-number] [stats {byte-count   bit-rate   packet-count   max-bit-rate}] [protocol protocol-name   top-n number]</pre> | <p>Displays the statistics gathered by the NBAR Protocol Discovery feature.</p> <ul style="list-style-type: none"> <li>(Optional) Enter keywords and arguments to fine-tune the statistics displayed. For more information on each of the keywords, refer to the <b>show ip nbar protocol-discovery</b> command in Cisco IOS Quality of Service Solutions Command Reference.</li> </ul> <p><b>Note</b> When you configure NBAR, you must enable Protocol Discovery on the interface.</p> |
| <pre>show policy-map target show policy-map show policy-map policy-name show policy-map interface interface-type interface-number</pre>                                                      | <p>Displays information about policy map.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                            |

Table 201: Clearing Application Visibility Statistics Commands

| Command                                     | Purpose                           |
|---------------------------------------------|-----------------------------------|
| <code>clear avc client mac stats</code>     | Clears the statistics per client. |
| <code>clear avc wlan wlan-name stats</code> | Clears the statistics per WLAN.   |

## Examples: Application Visibility and Control

### Examples: Application Visibility Configuration

This example shows how to create a flow record, create a flow monitor, apply the flow record to the flow monitor, and apply the flow monitor on a WLAN:

```
Device# configure terminal
Device(config)# flow record fr_v4
Device(config-flow-record)# match ipv4 protocol
Device(config-flow-record)# match ipv4 source address
Device(config-flow-record)# match ipv4 destination address
Device(config-flow-record)# match transport destination-port
Device(config-flow-record)# match flow direction
Device(config-flow-record)# match application name
Device(config-flow-record)# match wireless ssid
Device(config-flow-record)# collect counter bytes long
Device(config-flow-record)# collect counter packets long
Device(config-flow-record)# collect wireless ap mac address
Device(config-flow-record)# collect wireless client mac address
Device(config)#end
```

```
Device# configure terminal
Device# flow monitor fm_v4
Device(config-flow-monitor)# record fr_v4
Device(config-flow-monitor)# cache timeout active 1800
Device(config)#end
```

```
Device(config)#wlan wlan1
Device(config-wlan)#ip flow monitor fm_v4 input
Device(config-wlan)#ip flow mon fm-v4 output
Device(config)#end
```

## Examples: Application Visibility and Control QoS Configuration

This example shows how to create class maps with apply match protocol filters for application name, category, and subcategory:

```
Device# configure terminal
Device(config)# class-map cat-browsing
Device(config-cmap)# match protocol attribute category browsing
Device(config-cmap)#end
```

```
Device# configure terminal
Device(config)# class-map cat-fileshare
Device(config-cmap)# match protocol attribute category file-sharing
Device(config-cmap)#end
```

```
Device# configure terminal
Device(config)# class-map match-any subcat-terminal
Device(config-cmap)# match protocol attribute sub-category terminal
Device(config-cmap)#end
```

```
Device# configure terminal
Device(config)# class-map match-any webex-meeting
Device(config-cmap)# match protocol webex-meeting
Device(config-cmap)#end
```

This example shows how to create policy maps and define existing class maps for upstream QoS:

```
Device# configure terminal
Device(config)# policy-map test-avc-up
Device(config-pmap)# class cat-browsing
Device(config-pmap-c)# police 150000
Device(config-pmap-c)# set dscp 12
Device(config-pmap-c)#end
```

```
Device# configure terminal
Device(config)# policy-map test-avc-up
Device(config-pmap)# class cat-fileshare
Device(config-pmap-c)# police 1000000
Device(config-pmap-c)# set dscp 20
Device(config-pmap-c)#end
```

```
Device# configure terminal
Device(config)# policy-map test-avc-up
Device(config-pmap)# class subcat-terminal
Device(config-pmap-c)# police 120000
```

```

Device(config-pmap-c) # set dscp 15
Device(config-pmap-c) #end

Device# configure terminal
Device(config) # policy-map test-avc-up
Device(config-pmap) # class webex-meeting
Device(config-pmap-c) # police 5000000
Device(config-pmap-c) # set dscp 21
Device(config-pmap-c) #end

```

This example shows how to create policy maps and define existing class maps for downstream QoS:

```

Device# configure terminal
Device(config) # policy-map test-avc-down
Device(config-pmap) # class cat-browsing
Device(config-pmap-c) # police 200000
Device(config-pmap-c) # set dscp 10
Device(config-pmap-c) #end

Device# configure terminal
Device(config) # policy-map test-avc-up
Device(config-pmap) # class cat-fileshare
Device(config-pmap-c) # police 300000
Device(config-pmap-c) # set wlan user-priority 2
Device(config-pmap-c) # set dscp 20
Device(config-pmap-c) #end

Device# configure terminal
Device(config) # policy-map test-avc-up
Device(config-pmap) # class subcat-terminal
Device(config-pmap-c) # police 100000
Device(config-pmap-c) # set dscp 25
Device(config-pmap-c) #end

Device# configure terminal
Device(config) # policy-map test-avc-up
Device(config-pmap) # class webex-meeting
Device(config-pmap-c) # police 60000000
Device(config-pmap-c) # set dscp 41
Device(config-pmap-c) #end

```

This example shows how to apply defined QoS policy on a WLAN:

```

Device# configure terminal
Device(config) #wlan alpha
Device(config-wlan) #shut
Device(config-wlan) #end
Device(config-wlan) #service-policy client input test-avc-up
Device(config-wlan) #service-policy client output test-avc-down
Device(config-wlan) #no shut
Device(config-wlan) #end

```

## Example: Configuring QoS Attribute for Local Profiling Policy

The following example shows how to configure QoS attribute for a local profiling policy:

```

Device(config)# class-map type control subscriber match-all local_policy1_class
Device(config-filter-control-classmap)# match device-type android
Device(config)# service-template local_policy1_template
Device(config-service-template)# vlan 40
Device(config-service-template)# service-policy qos output local_policy1
Device(config)# policy-map type control subscriber local_policy1
Device(config-event-control-policymap)# event identity-update match-all
Device(config-class-control-policymap)# 1 class local_policy1_class do-until-success
Device(config-action-control-policymap)# 1 activate service-template local_policy1_template
Device(config)# wlan open_auth 9
Device(config-wlan)# client vlan VLAN40
Device(config-wlan)# service-policy type control subscriber local_policy1

```

## Additional References for Application Visibility and Control

### Related Documents

| Related Topic                  | Document Title                                                                                     |
|--------------------------------|----------------------------------------------------------------------------------------------------|
| System management commands     | <i>System Management Command Reference Guide, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i> |
| Flexible NetFlow configuration | <i>Flexible NetFlow Configuration Guide, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i>      |
| Flexible NetFlow commands      | <i>Flexible NetFlow Command Reference, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i>        |
| QoS configuration              | <i>QoS Configuration Guide, Cisco IOS XE Release 3E (Cisco WLC 5700 Series)</i>                    |
| QoS commands                   | <i>QoS Command Reference, Cisco IOS XE Release 3E (Cisco WLC 5700 Series)</i>                      |

### Standards and RFCs

| Standard/RFC | Title |
|--------------|-------|
| None         | —     |

### MIBs

| MIB                                      | MIBs Link                                                                                                                                                                                                                  |
|------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| All the supported MIBs for this release. | To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:<br><br><a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a> |

**Technical Assistance**

| Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Link                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p> | <a href="http://www.cisco.com/support">http://www.cisco.com/support</a> |

## Feature History and Information For Application Visibility and Control

| Release            | Feature Information                  |
|--------------------|--------------------------------------|
| Cisco IOS XE 3.3SE | This feature was introduced.         |
| Cisco IOS XE 3E    | AVC control with QoS was introduced. |



## CHAPTER 138

# Configuring Location Settings

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- [Information About Configuring Location Settings, on page 2561](#)
- [How to Configure Location Settings, on page 2562](#)
- [Monitoring Location Settings and NMSP Settings, on page 2566](#)
- [Examples: Location Settings Configuration, on page 2567](#)
- [Examples: NMSP Settings Configuration, on page 2567](#)
- [Additional References for Location Settings, on page 2567](#)
- [Feature History and Information For Performing Location Settings Configuration, on page 2568](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Configuring Location Settings

The device determines the location of client devices by gathering Received Signal Strength Indication (RSSI) measurements from access points all around the client of interest. The device can obtain location reports from up to 16 access points for clients, RFID tags, and rogue access points.

You can configure the path loss measurement (S60) request for normal clients or calibrating clients to improve location accuracy.

# How to Configure Location Settings

## Configuring Location Settings (CLI)

### Procedure

|               | Command or Action                                                                                                                                                                   | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                                                                   | Enters global configuration mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Step 2</b> | <b>location plm {calibrating [multiband   uniband]   client burst_interval}</b><br><b>Example:</b><br>Device(config)# <b>location plm client 100</b>                                | <p>Configures the path loss measurement (S60) request for calibrating clients or non-calibrating.</p> <p>The path loss measurement request improves the location accuracy. You can configure the <b>burst_interval</b> parameter for the normal, noncalibrating client from zero through 3600 seconds, and the default value is 60 seconds.</p> <p>You can configure the path loss measurement request for calibrating clients on the associated 802.11a or 802.11b/g radio or on the associated 802.11a/b/g radio.</p> <p>If a client does not send probes often or sends them only on a few channels, its location cannot be updated or cannot be updated accurately. The <b>location plm</b> command forces clients to send more packets on all channels. When a CCXv4 (or higher) client associates, the Device sends it a path loss measurement request, which instructs the client to transmit on the bands and channels that the access points are on (typically, channels 1, 6, and 11 for 2.4-GHz-only access points) at a configurable interval (such as 60 seconds) indefinitely.</p> |
| <b>Step 3</b> | <b>location rssi-half-life {calibrating-client   client   rogue-aps   tags } seconds</b><br><b>Example:</b><br>Device(config)# <b>location rssi-half-life calibrating-client 60</b> | <p>Configures the RSSI half life for the clients, calibrating clients, RFID tags, and rogue access points.</p> <p>You can enter the <b>location rssi-half-life</b> parameter value for the clients, calibrating clients, RFID tags, and rogue access points as 0, 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, or 300 seconds, and the default value is 0 seconds.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |



|               | Command or Action                                                                                                                                                                                                  | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               |                                                                                                                                                                                                                    | <p>Some client devices transmit at reduced power immediately after changing channels, and RF is variable, so RSSI values might vary considerably from packet to packet. The <b>location rssi-half-life</b> command increases accuracy by averaging nonuniformly arriving data using a configurable forget period (or half life).</p> <p><b>Note</b> We recommend that you do not use or modify the <b>location rssi-half-life</b> command.</p>                                                                                                                                                                                                                                                                                                         |
| <b>Step 4</b> | <p><b>location expiry</b> {<b>calibrating-client</b>   <b>client</b>   <b>rogue-aps</b>   <b>tags</b> } <i>timeout</i></p> <p><b>Example:</b></p> <pre>Device(config)# location expiry calibrating-client 50</pre> | <p>Configures the RSSI timeout value for the clients, calibrating clients, RFID tags, and rogue access points.</p> <p>You can enter the RSSI timeout value for the clients, RFID tags, and rogue access points from 5 through 3600 seconds, and the default value is 5 seconds.</p> <p>For the calibrating clients, you can enter the RSSI timeout value from 0 through 3600 seconds, and the default value is 5 seconds.</p> <p>Ensuring that recent, strong RSSIs are retained by the CPU is critical to location accuracy. The <b>location expiry</b> command enables you to specify the length of time after which old RSSI averages expire.</p> <p><b>Note</b> We recommend that you do not use or modify the <b>location expiry</b> command.</p> |
| <b>Step 5</b> | <p><b>location algorithm</b> {<b>rssi-average</b>   <b>simple</b>}</p> <p><b>Example:</b></p> <pre>Device(config)# location algorithm rssi-average</pre>                                                           | <p>Configures the algorithm used to average RSSI and signal-to-noise ratio (SNR) values.</p> <p>You can enter the <b>location algorithm rssi-average</b> command to specify a more accurate algorithm but requires more CPU overhead or the <b>location algorithm simple</b> command to specify a faster algorithm that requires low CPU overhead but provides less accuracy.</p> <p><b>Note</b> We recommend that you do not use or modify the <b>location algorithm</b> command.</p>                                                                                                                                                                                                                                                                 |

|                | Command or Action                                                                                                                                                                        | Purpose                                                                                                                                                                                  |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 6</b>  | <b>location admin-tag</b> <i>string</i><br><b>Example:</b><br>Device (config) # <b>location admin-tag</b>                                                                                | Sets administrative tag or site information for the location of client devices.                                                                                                          |
| <b>Step 7</b>  | <b>location civic-location identifier</b> { <i>identifier</i>   <i>host</i> }<br><b>Example:</b><br>Device (config) # <b>location civic-location identifier host</b>                     | Specifies civic location information.<br>You can set the civic location identifier either as a string or host.                                                                           |
| <b>Step 8</b>  | <b>location custom-location identifier</b> { <i>identifier</i>   <i>host</i> }<br><b>Example:</b><br>Device (config) # <b>location custom-location identifier host</b>                   | Specifies custom location information.<br>You can set the custom location identifier either as a string or host.                                                                         |
| <b>Step 9</b>  | <b>location geo-location identifier</b> { <i>identifier</i>   <i>host</i> }<br><b>Example:</b><br>Device (config) # <b>location geo-location identifier host</b>                         | Specifies geographical location information of the client devices.<br>You can set the location identifier either as a string or host.                                                    |
| <b>Step 10</b> | <b>location prefer</b> { <i>cdp</i>   <i>lldp-med</i>   <i>static</i> } <b>weight</b> <i>priority_value</i><br><b>Example:</b><br>Device (config) # <b>location prefer weight cdp 50</b> | Sets location information source priority.<br>You can enter the priority weight from zero through 255.                                                                                   |
| <b>Step 11</b> | <b>location rfid</b> { <i>status</i>   <i>timeout</i>   <i>vendor-name</i> }<br><b>Example:</b><br>Device (config) # <b>location rfid timeout 100</b>                                    | Configures RFID tag tracking options such as RFID tag status, RFID timeout value, and RFID tag vendor name.<br>You can enter the RFID timeout value in a range from 60 and 7200 seconds. |
| <b>Step 12</b> | <b>end</b><br><b>Example:</b><br>Device (config) # <b>end</b>                                                                                                                            | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                   |

### Example

## Modifying the NMSP Notification Interval for Clients, RFID Tags, and Rogues

NMSP manages communication between the Cisco Mobility Services Engine (Cisco MSE) and the controller for incoming and outgoing traffic. If your application requires more frequent location updates, you can modify

the NMSP notification interval (to a value between 1 and 180 seconds) for clients, active RFID tags, and rogue access points and clients.



**Note** The TCP port (16113) that the controller and Cisco MSE communicate over must be open (not blocked) on any firewall that exists between the controller and the Cisco MSE for NMSP to function.

### Procedure

|               | Command or Action                                                                                                                                                                                                                                                                     | Purpose                                                                                                                                                                                                           |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <code>configure terminal</code>                                                                                                                                                                                               | Enters global configuration mode.                                                                                                                                                                                 |
| <b>Step 2</b> | <b>nmosp notification interval</b> {attachment <i>seconds</i>   location <i>seconds</i>   rssi [clients <i>interval</i>   rfid <i>interval</i>   rogues [ap   client ] <i>interval</i> ]}<br><b>Example:</b><br>Device(config)# <code>nmosp notification interval rssi rfid 50</code> | Sets the NMSP notification interval value for clients, RFID tags, and rogue clients and access points.<br><br>You can enter the NMSP notification interval value for RSSI measurement from 1 through 180 seconds. |
| <b>Step 3</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <code>end</code>                                                                                                                                                                                                                     | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                                            |

## Modifying the NMSP Notification Threshold for Clients, RFID Tags, and Rogues

### Procedure

|               | Command or Action                                                                                                                                                      | Purpose                                                                                                                                                                                 |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <code>configure terminal</code>                                                                                | Enters global configuration mode.                                                                                                                                                       |
| <b>Step 2</b> | <b>location notify-threshold</b> {clients   rogues ap   tags } <i>threshold</i><br><b>Example:</b><br>Device(config)# <code>location notify-threshold clients 5</code> | Configures the NMSP notification threshold for clients, RFID tags, rogue clients, and access points.<br><br><i>threshold</i> - RSSI threshold value in db. Valid range is from 0 to 10. |
| <b>Step 3</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <code>end</code>                                                                                                      | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                  |

# Monitoring Location Settings and NMSP Settings

## Monitoring Location Settings (CLI)

This section describes the new commands for location settings.

The following commands can be used to monitor location settings on the .

**Table 202: Monitoring Location Settings Commands**

| Command                                            | Purpose                                             |
|----------------------------------------------------|-----------------------------------------------------|
| <b>show location summary</b>                       | Displays the current location configuration values. |
| <b>show location statistics rfid</b>               | Displays the location-based RFID statistics.        |
| <b>show location detail <i>client_mac_addr</i></b> | Displays the RSSI table for a particular client.    |

## Monitoring NMSP Settings (CLI)

The following commands can be used to monitor NMSP settings on the .

**Table 203: Monitoring NMSP Settings Commands**

| Command                                             | Purpose                                                                                 |
|-----------------------------------------------------|-----------------------------------------------------------------------------------------|
| <b>show nmsp attachment suppress interfaces</b>     | Displays the attachment suppress interfaces.                                            |
| <b>show nmsp capability</b>                         | Displays the NMSP capabilities.                                                         |
| <b>show nmsp notification interval</b>              | Displays the NMSP notification intervals.                                               |
| <b>show nmsp statistics connection</b>              | Displays the connection-specific NMSP counters.                                         |
| <b>show nmsp statistics summary</b>                 | Displays the common NMSP counters.                                                      |
| <b>show nmsp status</b>                             | Displays the status of active NMSP connections.                                         |
| <b>show nmsp subscription detail</b>                | Displays all of the mobility services to which the is subscribed.                       |
| <b>show nmsp subscription detail <i>ip_addr</i></b> | Displays details only for the mobility services subscribed to by a specific IP address. |
| <b>show nmsp subscription summary</b>               | Displays details for all of the mobility services to which the is subscribed.           |

## Examples: Location Settings Configuration

This example shows how to configure the path loss measurement (S60) request for calibrating client on the associated 802.11a or 802.11b/g radio:

```
Device# configure terminal
Device(config)# location plm calibrating uniband
Device(config)# end
Device# show location summary
```

This example shows how to configure the RSSI half life for a rouge access point:

```
Device# configure terminal
Device(config)# location rssi-half-life rogue-aps 20
Device(config)# end
Device# show location summary
```

## Examples: NMSP Settings Configuration

This example shows how to configure the NMSP notification interval for RFID tags:

```
Device# configure terminal
Device(config)# nmsp notification interval rssi rfid 50
Device(config)# end
Device# show nmsp notification interval
```

This example shows how to configure the NMSP notification interval for clients:

```
Device# configure terminal
Device(config)# nmsp notification interval rssi clients 180
Device(config)# end
Device# show nmsp notification interval
```

## Additional References for Location Settings

### Related Documents

| Related Topic              | Document Title                                                                               |
|----------------------------|----------------------------------------------------------------------------------------------|
| System management commands | <i>System Management Command Reference, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i> |

### Standards and RFCs

| Standard/RFC | Title |
|--------------|-------|
| None         | —     |

**MIBs**

| MIB                                      | MIBs Link                                                                                                                                                                                                              |
|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| All the supported MIBs for this release. | To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:<br><a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a> |

**Technical Assistance**

| Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Link                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p> | <a href="http://www.cisco.com/support">http://www.cisco.com/support</a> |

## Feature History and Information For Performing Location Settings Configuration

| Release            | Feature Information          |
|--------------------|------------------------------|
| Cisco IOS XE 3.2SE | This feature was introduced. |



## CHAPTER 139

# Configuring Voice and Video Parameters

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- [Prerequisites for Voice and Video Parameters, on page 2569](#)
- [Restrictions for Voice and Video Parameters, on page 2569](#)
- [Information About Configuring Voice and Video Parameters, on page 2570](#)
- [How to Configure Voice and Video Parameters, on page 2574](#)
- [Monitoring Voice and Video Parameters, on page 2584](#)
- [Configuration Examples for Voice and Video Parameters, on page 2586](#)
- [Additional References for Voice and Video Parameters, on page 2587](#)
- [Feature History and Information For Performing Voice and Video Parameters Configuration, on page 2588](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Voice and Video Parameters

You can confirm the following points before configuring voice and video parameters:

- Ensure that the device has access points connected to it.
- Configure SSID.

## Restrictions for Voice and Video Parameters

The following are the restrictions that you should keep in mind while configuring voice and video parameters:

- SIP CAC can be used for the 9971 Cisco phones that support TSPEC-based admission control. You can also use the phones that support Status code 17.

- SIP snooping is supported for providing voice priority to the non-TSPEC SIP phones.
- TSPEC for video CAC is not supported.
- Cisco 792x IP phones that are admitted as non-WMM devices with 11K enabled will experience audio problems with the phones.



---

**Note** Disable 11K for voice WLAN for all 792x Cisco IP phones that are admitted as non-WMM devices with 11K enabled. Upgrade the firmware on Cisco Unified Call Manager to 1.4.5 to resolve this issue. Refer to the Cisco Unified Call Manager configuration guide for more information.

---

## Information About Configuring Voice and Video Parameters

Three parameters on the device affect voice and/or video quality:

- Call Admission Control
- Expedited bandwidth requests
- Unscheduled automatic power save delivery

Call Admission Control (CAC) and UAPSD are supported on Cisco Compatible Extensions (CCX) v4 and v5; however, these parameters are also supported even without CCX but on any device implementing WMM (that supports 802.1e). Expedited bandwidth requests are supported only on CCXv5.

Traffic stream metrics (TSM) can be used to monitor and report issues with voice quality.

## Call Admission Control

Call Admission Control (CAC) enables an access point to maintain controlled quality of service (QoS) when the wireless LAN is experiencing congestion. The WMM protocol deployed in CCXv4 maintains QoS under differing network loads.

Two types of Over The Air (OTA) CAC are available: static-based CAC and load-based CAC.

The device supports the following QoS policies:

- User-defined policies: You can define your own QoS policies. You can have more control over these policies than the existing metal policies.
- System-defined precious metal policies: To support backward compatibility.
  - Platinum: Used for VoIP clients.
  - Gold: Used for video clients.
  - Silver: Used for best effort traffic.
  - Bronze: Used for NRT traffic.



## Static-Based CAC

Voice over WLAN applications supporting WMM and TSPEC can specify how much bandwidth or shared medium time is required to initiate a call. Bandwidth-based, or static, CAC enables the access point to determine whether it is capable of accommodating a particular call. The access point rejects the call if necessary in order to maintain the maximum allowed number of calls with acceptable quality.

The QoS setting for a WLAN determines the level of bandwidth-based CAC support. To use bandwidth-based CAC with voice applications, the WLAN must be configured for Platinum QoS. With bandwidth-based CAC, the access point bandwidth availability is determined based on the amount of bandwidth currently used by the access point clients, to which the bandwidth requested by the Voice over WLAN applications is added. If this total exceeds a configured bandwidth threshold, the new call is rejected.



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**Note** You must enable admission control (ACM) for CCXv4 clients that have WMM enabled. Otherwise, bandwidth-based CAC does not operate properly for these CCXv4 clients.

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## Load-Based CAC

Load-based CAC incorporates a measurement scheme that takes into account the bandwidth consumed by all traffic types (including that from clients), cochannel access point loads, and coallocated channel interference, for voice and video applications. Load-based CAC also covers the additional bandwidth consumption resulting from PHY and channel impairment.

In load-based CAC, the access point continuously measures and updates the utilization of the RF channel (that is, the mean time of bandwidth that has been exhausted), channel interference, and the additional calls that the access point can admit. The access point admits a new call only if the channel has enough unused bandwidth to support that call. By doing so, load-based CAC prevents oversubscription of the channel and maintains QoS under all conditions of WLAN loading and interference.



---

**Note** If you disable load-based CAC, the access points start using bandwidth-based CAC.

---

## IOSd Call Admission Control

IOSd Call Admission Control (CAC) controls bandwidth availability from device to access point.

You can configure class-based, unconditional packet marking features on your switch for CAC.

CAC is a concept that applies to voice and video traffic only—not data traffic. If an influx of data traffic oversubscribes a particular link in the network, queueing, buffering, and packet drop decisions resolve the congestion. The extra traffic is simply delayed until the interface becomes available to send the traffic, or, if traffic is dropped, the protocol or the end user initiates a timeout and requests a retransmission of the information.

Network congestion cannot be resolved in this manner when real-time traffic, sensitive to both latency and packet loss, is present, without jeopardizing the quality of service (QoS) expected by the users of that traffic. For real-time delay-sensitive traffic such as voice, it is better to deny network access under congestion conditions than to allow traffic onto the network to be dropped and delayed, causing intermittent impaired QoS and resulting in customer dissatisfaction.

CAC is therefore a deterministic and informed decision that is made before a voice call is established and is based on whether the required network resources are available to provide suitable QoS for the new call.

Based on the admit CAC CLI configuration in addition to the existing CAC algorithm, device allows either voice or video with TSPEC or SIP snooping. The **admit cac** CLI is mandatory for the voice call to pass through.

If the BSSID policer is configured for the voice or video traffic, then additional checks are performed on the packets.

## Expedited Bandwidth Requests

The expedited bandwidth request feature enables CCXv5 clients to indicate the urgency of a WMM traffic specifications (TSPEC) request (for example, an e911 call) to the WLAN. When the controller receives this request, it attempts to facilitate the urgency of the call in any way possible without potentially altering the quality of other TSPEC calls that are in progress.

You can apply expedited bandwidth requests to both bandwidth-based and load-based CAC. Expedited bandwidth requests are disabled by default. When this feature is disabled, the controller ignores all expedited requests and processes TSPEC requests as normal TSPEC requests.

The following table lists examples of TSPEC request handling for normal TSPEC requests and expedited bandwidth requests.

**Table 204: TSPEC Request Handling Examples**

| CAC Mode            | Reserved bandwidth for voice calls | Usage                                                              | Normal TSPEC Request | TSPEC with Expedited Bandwidth Request |
|---------------------|------------------------------------|--------------------------------------------------------------------|----------------------|----------------------------------------|
| Bandwidth-based CAC | 75% (default setting)              | Less than 75%                                                      | Admitted             | Admitted                               |
|                     |                                    | Between 75% and 90% (reserved bandwidth for voice calls exhausted) | Rejected             | Admitted                               |
|                     |                                    | More than 90%                                                      | Rejected             | Rejected                               |
| Load-based CAC      |                                    | Less than 75%                                                      | Admitted             | Admitted                               |
|                     |                                    | Between 75% and 85% (reserved bandwidth for voice calls exhausted) | Rejected             | Admitted                               |
|                     |                                    | More than 85%                                                      | Rejected             | Rejected                               |

<sup>30</sup> For bandwidth-based CAC, the voice call bandwidth usage is per access point radio and does not take into account cochannel access points. For load-based CAC, the voice call bandwidth usage is measured for the entire channel.

<sup>31</sup> Bandwidth-based CAC (consumed voice and video bandwidth) or load-based CAC (channel utilization [Pb]).



**Note** Admission control for TSPEC G711-20ms and G711-40 ms codec types are supported.

## U-APSD

Unscheduled automatic power save delivery (U-APSD) is a QoS facility defined in IEEE 802.11e that extends the battery life of mobile clients. In addition to extending battery life, this feature reduces the latency of traffic flow delivered over the wireless media. Because U-APSD does not require the client to poll each individual packet buffered at the access point, it allows delivery of multiple downlink packets by sending a single uplink trigger packet. U-APSD is enabled automatically when WMM is enabled.

## Traffic Stream Metrics

In a voice-over-wireless LAN (VoWLAN) deployment, traffic stream metrics (TSM) can be used to monitor voice-related metrics on the client-access point air interface. It reports both packet latency and packet loss. You can isolate poor voice quality issues by studying these reports.

The metrics consist of a collection of uplink (client side) and downlink (access point side) statistics between an access point and a client device that supports CCX v4 or later releases. If the client is not CCX v4 or CCXv5 compliant, only downlink statistics are captured. The client and access point measure these metrics. The access point also collects the measurements every 5 seconds, prepares 90-second reports, and then sends the reports to the controller. The controller organizes the uplink measurements on a client basis and the downlink measurements on an access point basis and maintains an hour's worth of historical data. To store this data, the controller requires 32 MB of additional memory for uplink metrics and 4.8 MB for downlink metrics.

TSM can be configured through either the GUI or the CLI on a per radio-band basis (for example, all 802.11a radios). The controller saves the configuration in flash memory so that it persists across reboots. After an access point receives the configuration from the controller, it enables TSM on the specified radio band.

This table shows the upper limit for TSM entries in different controller series.

| TSM Entries            | 5700          |
|------------------------|---------------|
| MAX AP TSM entries     | 100           |
| MAX Client TSM entries | 250           |
| MAX TSM entries        | 100*250=25000 |



**Note** Once the upper limit is reached, additional TSM entries cannot be stored and sent to WCS or NCS. If client TSM entries are full and AP TSM entries are available, then only the AP entries are stored, and viceversa. This leads to partial output. TSM cleanup occurs every one hour. Entries are removed only for those APs and clients that are not in the system.

## Information About Configuring Voice Prioritization Using Preferred Call Numbers

You can configure a device to provide support for SIP calls from VoWLAN clients that do not support TSPEC-based calls. This feature is known as SIP CAC support. If bandwidth is available in the configured voice pool, the SIP call uses the normal flow and the device allocates the bandwidth to those calls.

You can also prioritize up to six preferred call numbers. When a call comes to one of the configured preferred numbers, the device does not check the configured maximum voice bandwidth. The device allocates the bandwidth needed for the call, even if it exceeds the maximum bandwidth for voice configured for voice CAC. The preferred call will be rejected if bandwidth allocation exceeds 85% of the radio bandwidth. The bandwidth allocation is 85 percent of the entire bandwidth pool, not just from the maximum configured voice pool. The bandwidth allocation is the same even for roaming calls.

You must configure the following parameters before configuring voice prioritization:

- Set WLAN QoS to allow voice calls to pass through.
- Enable ACM for the radio.
- Enable SIP call snooping on the WLAN.

## Information About Enhanced Distributed Channel Access Parameters

Enhanced Distributed Channel Access (EDCA) parameters are designed to provide preferential wireless channel access for voice, video, and other quality of service (QoS) traffic.

## How to Configure Voice and Video Parameters

### Configuring Voice Parameters (CLI)

#### Before you begin

Ensure that you have configured SIP-based CAC.

You should have created a class map for CAC before beginning this procedure.

#### Procedure

|               | Command or Action                                                               | Purpose                                                                                                                                           |
|---------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>show wlan summary</b><br><b>Example:</b><br>Device# <b>show wlan summary</b> | Specifies all of the WLANs configured on the device.                                                                                              |
| <b>Step 2</b> | <b>show wlan wlan_id</b><br><b>Example:</b><br>Device# <b>show wlan 25</b>      | Specifies the WLAN that you plan to modify. For voice over WLAN, ensure that the WLAN is configured for WMM and the QoS level is set to Platinum. |

|                | Command or Action                                                                                                                                                                                 | Purpose                                                                                                                                                                                                                                                                              |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 3</b>  | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                                                                                 | Enters global configuration mode.                                                                                                                                                                                                                                                    |
| <b>Step 4</b>  | <b>policy-map <i>policy-map name</i></b><br><b>Example:</b><br>Device (config)# <b>policy-map test_2000</b><br>Device (config-pmap)#                                                              | Enters policy map configuration mode.<br><br>Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.<br><br>In WLAN, you need to configure service-policy for these commands to take effect.                                    |
| <b>Step 5</b>  | <b>class {<i>class-name</i>   class-default}</b><br><b>Example:</b><br>Device (config-pmap)# <b>class test_1000</b><br>Device (config-pmap-c)#                                                    | Enters policy class map configuration mode. Specifies the name of the class whose policy you want to create or change.<br><br>Specifies the name of the class whose policy you want to create or change.<br><br>You can also create a system default class for unclassified packets. |
| <b>Step 6</b>  | <b>admit cac wmm-tspec</b><br><b>Example:</b><br>Device (config-pmap-c)# <b>admit cac wmm-tspec</b><br>Device (config-pmap-c)#                                                                    | (Optional) Admits the request for Call Admission Control (CAC) for policy map.                                                                                                                                                                                                       |
| <b>Step 7</b>  | <b>service-policy <i>policy-map name</i></b><br><b>Example:</b><br>Device (config-pmap-c)# <b>service-policy test_2000</b><br>Device (config-pmap-c)#                                             | Configures the QoS service policy.                                                                                                                                                                                                                                                   |
| <b>Step 8</b>  | <b>end</b><br><b>Example:</b><br>Device (config)# <b>end</b>                                                                                                                                      | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                                                                                                                  |
| <b>Step 9</b>  | <b>wlan <i>wlan_profile_name</i> <i>wlan_ID</i> <i>SSID_network_name</i> wlan shutdown</b><br><b>Example:</b><br>Device (config)# <b>wlan wlan1</b><br>Device (config-wlan)# <b>wlan shutdown</b> | Disables all WLANs with WMM enabled prior to changing the video parameters.                                                                                                                                                                                                          |
| <b>Step 10</b> | <b>wlan <i>wlan_profile_name</i> <i>wlan_ID</i> <i>SSID_network_name</i></b>                                                                                                                      | Disables all WLANs with WMM enabled prior to changing the voice parameters.                                                                                                                                                                                                          |

|                | Command or Action                                                                                                                                                                    | Purpose                                                                             |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|                | <b>Example:</b><br>Device(config)# <b>wlan wlan1</b><br>Device(config-wlan)# <b>wlan shutdown</b>                                                                                    |                                                                                     |
| <b>Step 11</b> | <b>wlan wlan_name call-snoop</b><br><b>Example:</b><br>Device(config)# <b>wlan wlan1 call-snoop</b>                                                                                  | Enables the call-snooping on a particular WLAN.                                     |
| <b>Step 12</b> | <b>wlan wlan_name service-policy input input_policy_name</b><br><b>Example:</b><br>Device(config)# <b>wlan wlan1</b><br>Device(config-wlan)# <b>service-policy input platinum-up</b> | Configures input SSID policy on a particular WLAN to voice.                         |
| <b>Step 13</b> | <b>wlan wlan_name service-policy output output_policy_name</b><br><b>Example:</b><br>Device(config)# <b>wlan wlan1</b><br>Device(config-wlan)# <b>service-policy output platinum</b> | Configures output SSID policy on a particular WLAN to voice.                        |
| <b>Step 14</b> | <b>wlan wlan_name service-policy input ingress_policy_name</b><br><b>Example:</b><br>Device(config)# <b>wlan wlan1</b><br>Device(config-wlan)# <b>service-policy input policy1</b>   | Configures ingress SSID policy on a particular WLAN as user-defined policy.         |
| <b>Step 15</b> | <b>wlan wlan_name service-policy output egress_policy_name</b><br><b>Example:</b><br>Device(config)# <b>wlan wlan1</b><br>Device(config-wlan)# <b>service-policy output policy2</b>  | Configures egress SSID policy on a particular WLAN as user-defined policy.          |
| <b>Step 16</b> | <b>ap dot11 {5ghz   24ghz} shutdown</b><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz shutdown</b>                                                                          | Disables the radio network.                                                         |
| <b>Step 17</b> | <b>ap dot11 {5ghz   24ghz} cac voice sip</b><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz cac voice sip</b>                                                                | Enables or disables SIP IOSd CAC for the 802.11a or 802.11b/g network.              |
| <b>Step 18</b> | <b>ap dot11 {5ghz   24ghz} cac voice acm</b><br><b>Example:</b>                                                                                                                      | Enables or disables bandwidth-based voice CAC for the 802.11a or 802.11b/g network. |

|                | Command or Action                                                                                                                                                 | Purpose                                                                                                                                                                                                                                                                                           |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | Device (config) # <b>ap dot11 5ghz cac voice acm</b>                                                                                                              |                                                                                                                                                                                                                                                                                                   |
| <b>Step 19</b> | <b>ap dot11 {5ghz   24ghz} cac voice max-bandwidth <i>bandwidth</i></b><br><b>Example:</b><br>Device (config) # <b>ap dot11 5ghz cac voice max-bandwidth 85</b>   | Sets the percentage of maximum bandwidth allocated to clients for voice applications on the 802.11a or 802.11b/g network.<br><br>The bandwidth range is 5 to 85%, and the default value is 75%. Once the client reaches the value specified, the access point rejects new videos on this network. |
| <b>Step 20</b> | <b>ap dot11 {5ghz   24ghz} cac voice roam-bandwidth <i>bandwidth</i></b><br><b>Example:</b><br>Device (config) # <b>ap dot11 5ghz cac voice roam-bandwidth 10</b> | Sets the percentage of maximum allocated bandwidth reserved for roaming voice clients.<br><br>The bandwidth range is 0 to 25%, and the default value is 6%. The device reserves this much bandwidth from the maximum allocated bandwidth for roaming voice clients.                               |
| <b>Step 21</b> | <b>no wlan shutdown</b><br><b>Example:</b><br>Device (config-wlan) # <b>no wlan shutdown</b>                                                                      | Reenables all WLANs with WMM enabled.                                                                                                                                                                                                                                                             |
| <b>Step 22</b> | <b>no ap dot11 {5ghz   24ghz} shutdown</b><br><b>Example:</b><br>Device (config) # <b>no ap dot11 5ghz shutdown</b>                                               | Reenables the radio network.                                                                                                                                                                                                                                                                      |
| <b>Step 23</b> | <b>end</b><br><b>Example:</b><br>Device (config) # <b>end</b>                                                                                                     | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                                                                                                                            |

### Example

## Configuring Video Parameters (CLI)

### Procedure

|               | Command or Action                                                               | Purpose                                              |
|---------------|---------------------------------------------------------------------------------|------------------------------------------------------|
| <b>Step 1</b> | <b>show wlan summary</b><br><b>Example:</b><br>Device# <b>show wlan summary</b> | Specifies all of the WLANs configured on the device. |
| <b>Step 2</b> | <b>show wlan <i>wlan_id</i></b>                                                 | Specifies the WLAN that you plan to modify.          |

|                | Command or Action                                                                                                                                             | Purpose                                                                                                                                                                                                                                                                              |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | <b>Example:</b><br>Device# <code>show wlan 25</code>                                                                                                          |                                                                                                                                                                                                                                                                                      |
| <b>Step 3</b>  | <b>configure terminal</b><br><b>Example:</b><br>Device# <code>configure terminal</code>                                                                       | Enters global configuration mode.                                                                                                                                                                                                                                                    |
| <b>Step 4</b>  | <b>policy-map <i>policy-map name</i></b><br><b>Example:</b><br>Device (config)# <code>policy-map test_2000</code><br>Device (config-pmap) #                   | Enters policy map configuration mode.<br><br>Creates or modifies a policy map that can be attached to one or more interfaces to specify a service policy.<br><br>In WLAN, you need to configure service-policy for these commands to take effect.                                    |
| <b>Step 5</b>  | <b>class {<i>class-name</i>   <i>class-default</i>}</b><br><b>Example:</b><br>Device (config-pmap) # <code>class test_1000</code><br>Device (config-pmap-c) # | Enters policy class map configuration mode. Specifies the name of the class whose policy you want to create or change.<br><br>Specifies the name of the class whose policy you want to create or change.<br><br>You can also create a system default class for unclassified packets. |
| <b>Step 6</b>  | <b>admit cac wmm-tspec</b><br><b>Example:</b><br>Device (config-pmap-c) # <code>admit cac wmm-tspec</code><br>Device (config-pmap-c) #                        | (Optional) Admits the request for Call Admission Control (CAC) for policy map.                                                                                                                                                                                                       |
| <b>Step 7</b>  | <b>service-policy <i>policy-map name</i></b><br><b>Example:</b><br>Device (config-pmap-c) # <code>service-policy test_2000</code><br>Device (config-pmap-c) # | Configures the QoS service policy.                                                                                                                                                                                                                                                   |
| <b>Step 8</b>  | <b>end</b><br><b>Example:</b><br>Device (config) # <code>end</code>                                                                                           | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                                                                                                                  |
| <b>Step 9</b>  | <b>wlan <i>wlan_profile_name</i></b><br><b>Example:</b><br>Device (config) # <code>wlan wlan1</code><br>Device (config-wlan) # <code>wlan shutdown</code>     | Disables all WLANs with WMM enabled prior to changing the video parameters.                                                                                                                                                                                                          |
| <b>Step 10</b> | <b>ap dot11 {<i>5ghz</i>   <i>24ghz</i>} shutdown</b>                                                                                                         | Disables the radio network.                                                                                                                                                                                                                                                          |



|                | Command or Action                                                                                                                                              | Purpose                                                                                                                                                                                                                                                                                                                                                                           |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | <b>Example:</b><br>Device(config)# <b>ap dot11 5ghz shutdown</b>                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Step 11</b> | <b>ap dot11 {5ghz   24ghz} cac video acm</b><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz cac video acm</b>                                          | Enables or disables bandwidth-based video CAC for the 802.11a or 802.11b/g network.                                                                                                                                                                                                                                                                                               |
| <b>Step 12</b> | <b>ap dot11 {5ghz   24ghz} cac video load-based</b><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz cac video load-based</b>                            | Configures the load-based CAC method.<br><br>If you do not enter this command, then the default static CAC is applied.                                                                                                                                                                                                                                                            |
| <b>Step 13</b> | <b>ap dot11 {5ghz   24ghz} cac video max-bandwidth <i>bandwidth</i></b><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz cac video max-bandwidth 20</b>  | Sets the percentage of maximum bandwidth allocated to clients for video applications on the 802.11a or 802.11b/g network.<br><br>The bandwidth range is 5 to 85%, and the default value is 75%. The default value is 0, which means no bandwidth request control. The sum of the voice bandwidth and video bandwidth should not exceed 85% or configured maximum media bandwidth. |
| <b>Step 14</b> | <b>ap dot11 {5ghz   24ghz} cac video roam-bandwidth <i>bandwidth</i></b><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz cac video roam-bandwidth 9</b> | Sets the percentage of maximum allocated bandwidth reserved for roaming clients for video.<br><br>The bandwidth range is 0 to 25%, and the default value is 0%.                                                                                                                                                                                                                   |
| <b>Step 15</b> | <b>no wlan shutdown <i>wlan_id</i></b><br><b>Example:</b><br>Device(config-wlan)# <b>no wlan shutdown 25</b>                                                   | Reenables all WLANs with WMM enabled.                                                                                                                                                                                                                                                                                                                                             |
| <b>Step 16</b> | <b>no ap dot11 {5ghz   24ghz} shutdown</b><br><b>Example:</b><br>Device(config)# <b>no ap dot11 5ghz shutdown</b>                                              | Reenables the radio network.                                                                                                                                                                                                                                                                                                                                                      |
| <b>Step 17</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b>                                                                                                    | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                                                                                                                                                                                                            |

## Example

## Configuring SIP-Based CAC (CLI)

SIP CAC controls the total number of SIP calls that can be made.

### Procedure

|               | Command or Action                                                                                                                        | Purpose                                                                                                             |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                        | Enters global configuration mode.                                                                                   |
| <b>Step 2</b> | <b>wlan wlan-name</b><br><b>Example:</b><br>Device (config)# <b>wlan qos-wlan</b><br>Device (config-wlan)#                               | Enters WLAN configuration submode.                                                                                  |
| <b>Step 3</b> | <b>call-snoop</b><br><b>Example:</b><br>Device (config-wlan)# <b>call-snoop</b>                                                          | Enables the call-snooping feature for a particular WLAN.                                                            |
| <b>Step 4</b> | <b>service-policy [client] input policy-map name</b><br><b>Example:</b><br>Device (config-wlan)# <b>service-policy input platinum-up</b> | Assigns a policy map to WLAN input traffic. Ensure that you provide QoS policy to voice for input traffic.          |
| <b>Step 5</b> | <b>service-policy [client] output policy-map name</b><br><b>Example:</b><br>Device (config-wlan)# <b>service-policy output platinum</b>  | Assigns policy map to WLAN output traffic. Ensure that you provide QoS policy to voice for output traffic.          |
| <b>Step 6</b> | <b>end</b><br><b>Example:</b><br>Device (config)# <b>end</b>                                                                             | Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |
| <b>Step 7</b> | <b>show wlan {wlan-id   wlan-name}</b><br><b>Example:</b><br>Device# <b>show wlan qos-wlan</b>                                           | Verifies the configured QoS policy on the WLAN.                                                                     |
| <b>Step 8</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                        | Enters global configuration mode.                                                                                   |

|                | Command or Action                                                                                                               | Purpose                                                                                                                |
|----------------|---------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| <b>Step 9</b>  | <b>ap dot11 {5ghz   24ghz} cac {voice   video} acm</b><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz cac voice acm</b> | Enables the ACM static on the radio.<br>When enabling SIP snooping, use the static CAC, not the load-based CAC.        |
| <b>Step 10</b> | <b>ap dot11 {5ghz   24ghz} cac voice sip</b><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz cac voice sip</b>           | Configures SIP-based CAC.                                                                                              |
| <b>Step 11</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <b>end</b>                                                                     | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

### Example

## Configuring a Preferred Call Number (CLI)

### Before you begin

You must set the following parameters before configuring a preferred call number.

- Set WLAN QoS to voice.
- Enable ACM for the radio.
- Enable SIP call snooping on the WLAN.
- Enable SIP-based CAC.

### Procedure

|               | Command or Action                                                                                                                      | Purpose                                 |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                      | Enters global configuration mode.       |
| <b>Step 2</b> | <b>wlan wlan-name qos platinum</b><br><b>Example:</b><br>Device(config)# <b>wlan wlan1</b><br>Device(config-wlan)# <b>qos platinum</b> | Sets QoS to voice on a particular WLAN. |

|               | Command or Action                                                                                                                                     | Purpose                                                                                                                |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| <b>Step 3</b> | <b>ap dot11 {5ghz   24ghz} cac {voice   video} acm</b><br><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz cac voice acm</b>                   | Enables the static ACM on the radio.<br><br>When enabling SIP snooping, use the static CAC, not the load-based CAC.    |
| <b>Step 4</b> | <b>wlan wlan-name</b><br><br><b>Example:</b><br>Device(config)# <b>wlan wlan1</b><br><br>Device(config-wlan)# <b>call-snoop</b>                       | Enables the call-snooping feature for a particular WLAN.                                                               |
| <b>Step 5</b> | <b>wireless sip preferred-call-no call_index call_number</b><br><br><b>Example:</b><br>Device(config)# <b>wireless sip preferred-call-no 1 555333</b> | Adds a new preferred call.                                                                                             |
| <b>Step 6</b> | <b>no wireless sip preferred-call-no call_index</b><br><br><b>Example:</b><br>Device(config)# <b>no wireless sip preferred-call-no 1</b>              | Removes a preferred call.                                                                                              |
| <b>Step 7</b> | <b>end</b><br><br><b>Example:</b><br>Device(config)# <b>end</b>                                                                                       | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode. |

**Example**

## Configuring EDCA Parameters (CLI)

**Procedure**

|               | Command or Action                                                                                                | Purpose                           |
|---------------|------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><br><b>Example:</b><br>Device# <b>configure terminal</b>                            | Enters global configuration mode. |
| <b>Step 2</b> | <b>ap dot11 {5ghz   24ghz } shutdown</b><br><br><b>Example:</b><br>Device(config)# <b>ap dot11 5ghz shutdown</b> | Disables the radio network.       |

|               | Command or Action                                                                                                                                                                                                                                   | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 3</b> | <p><b>ap dot11 {5ghz   24ghz} edca-parameters {custom-voice   fastlane   optimized-video-voice   optimized-voice   svp-voice   wmm-default}</b></p> <p><b>Example:</b></p> <pre>Device(config)# ap dot11 5ghz edca-parameters optimized-voice</pre> | <p>Enables specific EDCA parameters for the 802.11a or 802.11b/g network.</p> <ul style="list-style-type: none"> <li>• <b>custom-voice</b>—Enables custom voice parameters for the 802.11a or 802.11b/g network.</li> <li>• <b>fastlane</b>—Enables the fastlane parameters for the 802.11a or 802.11b/g network.</li> <li>• <b>optimized-video-voice</b>—Enables EDCA voice-optimized and video-optimized parameters for the 802.11a or 802.11b/g network. Choose this option when both voice and video services are deployed on your network.</li> <li>• <b>optimized-voice</b>—Enables non-SpectraLink voice-optimized profile parameters for the 802.11a or 802.11b/g network. Choose this option when voice services other than SpectraLink are deployed on your network.</li> <li>• <b>svp-voice</b>—Enables SpectraLink voice-priority parameters for the 802.11a or 802.11b/g network. Choose this option if SpectraLink phones are deployed on your network to improve the quality of calls.</li> <li>• <b>wmm-default</b>—Enables the Wi-Fi Multimedia (WMM) default parameters for the 802.11a or 802.11b/g network. This is the default option. Choose this option when voice or video services are not deployed on your network.</li> </ul> |
| <b>Step 4</b> | <p><b>no ap dot11 {5ghz   24ghz} shutdown</b></p> <p><b>Example:</b></p> <pre>Device(config)# no ap dot11 5ghz shutdown</pre>                                                                                                                       | Re-enables the radio network.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Step 5</b> | <p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>                                                                                                                                                                             | Returns to privileged EXEC mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Step 6</b> | <p><b>show ap dot11 {5ghz   24ghz} network</b></p> <p><b>Example:</b></p> <pre>Device# show ap dot11 5ghz network</pre>                                                                                                                             | Displays the current status of MAC optimization for voice.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

# Monitoring Voice and Video Parameters

This section describes the new commands for the voice and video parameters.

The following commands can be used to monitor voice and video parameters.

**Table 205: Monitoring Voice Parameters Commands**

| Command                                                          | Purpose                                                                                                                                                                                                                                                                                                                                                                                                    |
|------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>show ap dot11 {5ghz   24ghz} network</b>                      | Displays the radio-based statistics for voice.                                                                                                                                                                                                                                                                                                                                                             |
| <b>show ap name <i>ap_name</i> dot11 24ghz tsm all</b>           | Displays the TSM voice metrics and current status of MAC optimization for voice.                                                                                                                                                                                                                                                                                                                           |
| <b>show ap name <i>apname</i> cac voice</b>                      | Displays the information about CAC for a particular access point.                                                                                                                                                                                                                                                                                                                                          |
| <b>show client detail <i>client_mac</i></b>                      | Displays the U-APSD status for a particular client.                                                                                                                                                                                                                                                                                                                                                        |
| <b>show policy-map interface wireless client</b>                 | Displays the video client policy details.                                                                                                                                                                                                                                                                                                                                                                  |
| <b>show access-list</b>                                          | Displays the video client dynamic access-list from the device.                                                                                                                                                                                                                                                                                                                                             |
| <b>show wireless client voice diag status</b>                    | Displays information about whether voice diagnostics are enabled or disabled. If enabled, this also displays information about the clients in the watch list and the time remaining for the diagnostics of the voice call.<br><br><b>Note</b> To work on voice diagnostics CLIs, you need to enter the following command: <b>debug voice-diagnostic mac-addr <i>client_mac_01</i> <i>client_mac_02</i></b> |
| <b>show wireless client voice diag tspec</b>                     | Displays the TSPEC information sent from the clients that are enabled for voice diagnostics.                                                                                                                                                                                                                                                                                                               |
| <b>show wireless client voice diag qos-map</b>                   | Displays information about the QoS/DSCP mapping and packet statistics in each of the four queues: VO, VI, BE, BK. The different DSCP values are also displayed.                                                                                                                                                                                                                                            |
| <b>show wireless client voice diag rssi</b>                      | Display the client's RSSI values in the last 5 seconds when voice diagnostics is enabled.                                                                                                                                                                                                                                                                                                                  |
| <b>show client voice-diag roam-history</b>                       | Displays information about the last three roaming calls. The output contains the timestamp, access point associated with roaming, roaming reason, and if there is a roaming failure, reason for roaming-failure.                                                                                                                                                                                           |
| <b>show policy-map interface wireless mac <i>mac-address</i></b> | Displays information about the voice and video data packet statistics.                                                                                                                                                                                                                                                                                                                                     |
| <b>show wireless media-stream client summary</b>                 | Displays a summary of the media stream and video client information.                                                                                                                                                                                                                                                                                                                                       |

|                                                          |                                                                        |
|----------------------------------------------------------|------------------------------------------------------------------------|
| <b>show controllers d0   b queue</b>                     | Displays which queue the packets are going through on an access point. |
| <b>show platform qos queue stats</b><br><i>interface</i> | Displays which queue packets are going through from the device.        |

You can monitor the video parameters using the following commands.

**Table 206: Monitoring Video Parameters Commands**

| <b>Command</b>                                                        | <b>Purpose</b>                                                                                                                                         |
|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>show ap join stats summary</b> <i>ap_mac</i>                       | Displays the last join error detail for a specific access point.                                                                                       |
| <b>show ip igmp snooping wireless mgid</b>                            | Displays the TSM voice metrics and current status of MAC optimization for voice.                                                                       |
| <b>show wireless media-stream multicast-direct state</b>              | Displays the media stream multicast-direct parameters.                                                                                                 |
| <b>show wireless media-stream group summary</b>                       | Displays the summary of the media stream and client information.                                                                                       |
| <b>show wireless media-stream group detail</b><br><i>group_name</i>   | Displays the details of a specific media-stream group.                                                                                                 |
| <b>show wireless media-stream client summary</b>                      | Displays the details for a set of media-stream clients.                                                                                                |
| <b>show wireless media-stream client detail</b><br><i>group_name</i>  | Displays the details for a set of media-stream clients.                                                                                                |
| <b>show ap dot11 {5ghz   24ghz} media-stream rrc</b>                  | Display the details of media stream.                                                                                                                   |
| <b>show wireless media-stream message details</b>                     | Displays information about the message configuration.                                                                                                  |
| <b>show ap name</b> <i>ap-name</i> <b>auto-rf dot11 5ghz   i Util</b> | Displays the details of channel utilization.                                                                                                           |
| <b>show controllers d0   b queue</b>                                  | Displays which queue the packets are going through on an access point based on 2.4- and 5-GHz bands.                                                   |
| <b>show controllers d1   b queue</b>                                  | Displays which queue the packets are going through on an access point based on 2.4- and 5-GHz bands.                                                   |
| <b>show cont d1   b Media</b>                                         | Displays the video metric details on the band A or B.                                                                                                  |
| <b>show capwap mcast mgid all</b>                                     | Displays information about all of the multicast groups and their corresponding multicast group identifications (MGIDs) associated to the access point. |
| <b>show capwap mcast mgid id</b> <i>id</i>                            | Displays information about all of the video clients joined to the multicast group in a specific MGID.                                                  |

# Configuration Examples for Voice and Video Parameters

## Example: Configuring Voice and Video

### Configuring Egress SSID Policy for Voice and Video

The following example shows how to create and configure an egress SSID policy for voice and video:

```
table-map egress_ssid_tb
  map from 24 to 24
  map from 34 to 34
  map from 46 to 46
  default copy

class-map match-any voice
  match dscp ef
class-map match-any video
  match dscp af41

policy-map ssid-cac
class class-default
  shape average 25000000
  set dscp dscp table egress_ssid_tb
  queue-buffers ratio 0
  service-policy ssid-child-cac

policy-map ssid-child-cac
class voice
  priority level 1
  police 5000000
  conform-action transmit
  exceed-action drop
  admit cac wmm-tspec
  rate 1000
  wlan-up 6 7
class video
  priority level 2
  police 10000000
  conform-action transmit
  exceed-action drop
  admit cac wmm-tspec
  rate 3000
  wlan-up 4 5
```

### Configuring Ingress SSID Policy for Voice and Video

The following example shows how to create and configure an ingress SSID policy for voice and video:

```
table-map up_to_dscp
  map from 0 to 0
  map from 1 to 8
  map from 2 to 8
  map from 3 to 0
  map from 4 to 34
  map from 5 to 34
  map from 6 to 46
  map from 7 to 48
  default copy
```



```

policy-map ingress_ssid
  class class-default
    set dscp wlan user-priority table up_to_dscp

```

### Configuring Egress Port Policy Voice and Video

The following example shows how to create and configure an egress port policy for voice and video:

```

policy-map port_child_policy
  class non-client-nrt-class
    bandwidth remaining ratio 10

  class voice
    priority level 1
    police rate 3000000

  class video
    priority level 2
    police rate 4000000

```

### Applying Ingress and Egress SSID policies for Voice and Video on a WLAN

The following example shows how to apply ingress and egress SSID policies for voice and video on a WLAN:

```

wlan voice_video 1 voice_video
  service-policy input ingress_ssid
  service-policy output ssid-cac

```

## Additional References for Voice and Video Parameters

### Related Documents

| Related Topic             | Document Title                                                                           |
|---------------------------|------------------------------------------------------------------------------------------|
| Multicast configuration   | <i>Multicast Configuration Guide, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i>   |
| VideoStream configuration | <i>VideoStream Configuration Guide, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i> |

### Standards and RFCs

| Standard/RFC | Title |
|--------------|-------|
| None         | —     |

**MIBs**

| MIB                                      | MIBs Link                                                                                                                                                                                                              |
|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| All the supported MIBs for this release. | To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:<br><a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a> |

**Technical Assistance**

| Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Link                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p> | <a href="http://www.cisco.com/support">http://www.cisco.com/support</a> |

## Feature History and Information For Performing Voice and Video Parameters Configuration

| Release            | Feature Information          |
|--------------------|------------------------------|
| Cisco IOS XE 3.2SE | This feature was introduced. |



## CHAPTER 140

# Configuring RFID Tag Tracking

- [Finding Feature Information, on page 2589](#)
- [Information About Configuring RFID Tag Tracking, on page 2589](#)
- [How to Configure RFID Tag Tracking, on page 2589](#)
- [Monitoring RFID Tag Tracking Information, on page 2590](#)
- [Additional References RFID Tag Tracking, on page 2591](#)
- [Feature History and Information For Performing RFID Tag Tracking Configuration , on page 2592](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Configuring RFID Tag Tracking

The device enables you to configure radio-frequency identification (RFID) tag tracking. RFID tags are small wireless devices that are affixed to assets for real-time location tracking. They operate by advertising their location using special 802.11 packets, which are processed by access points, the controller, and the location appliance.

## How to Configure RFID Tag Tracking

### Configuring RFID Tag Tracking (CLI)

#### Procedure

|        | Command or Action                 | Purpose                    |
|--------|-----------------------------------|----------------------------|
| Step 1 | <code>location rfid status</code> | Enables RFID tag tracking. |

|               | Command or Action                                                                                                                                       | Purpose                                                                                                                                                                                                                                                                                                                                                                                               |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | <b>Example:</b><br>Device(config)# <b>location rfid status</b>                                                                                          | By default, RFID tag tracking is enabled.                                                                                                                                                                                                                                                                                                                                                             |
| <b>Step 2</b> | (Optional) <b>no location rfid status</b><br><b>Example:</b><br>Device(config)# <b>no location rfid status</b>                                          | Disables RFID tag tracking.                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Step 3</b> | <b>location rfid timeout</b> <i>seconds</i><br><b>Example:</b><br>Device(config)# <b>location rfid timeout</b><br><b>1500</b>                           | Specifies a static timeout value (between 60 and 7200 seconds).<br><br>The static timeout value is the amount of time that the device maintains tags before expiring them. For example, if a tag is configured to beacon every 30 seconds, we recommend that you set the timeout value to 90 seconds (approximately three times the beacon value). The default value is 1200 seconds.                 |
| <b>Step 4</b> | <b>location rfid mobility vendor-name</b> <i>name</i><br><b>Example:</b><br>Device(config)# <b>location rfid mobility</b><br><b>vendor-name Aerosct</b> | Enables RFID tag mobility for specific tags. When you enter the <b>location rfid mobility vendor-name</b> command, tags are unable to obtain a DHCP address for client mode when attempting to select and/or download a configuration.<br><br><b>Note</b> These commands can be used only for Pango tags. Therefore, the only valid entry for <b>vendor_name</b> is “pango” in all lowercase letters. |
| <b>Step 5</b> | (Optional) <b>no location rfid mobility</b> <i>name</i><br><b>Example:</b><br>Device(config)# <b>no location rfid mobility</b><br><b>test</b>           | Disables RFID tag mobility for specific tags. When you enter the <b>no location rfid mobility</b> command, tags can obtain a DHCP address. If a tag roams from one subnet to another, it obtains a new address rather than retaining the anchor state.                                                                                                                                                |

## Monitoring RFID Tag Tracking Information

This section describes the new commands for the RFID tag tracking Information.

The following commands can be used to monitor the RFID tag tracking Information on the .

*Table 207: Monitoring RFID Tag Tracking Information Commands*

| Command                          | Purpose                                                   |
|----------------------------------|-----------------------------------------------------------|
| <b>show location rfid config</b> | Displays the current configuration for RFID tag tracking. |

|                                                     |                                                                     |
|-----------------------------------------------------|---------------------------------------------------------------------|
| <b>show location rfid detail</b> <i>mac_address</i> | Displays the detailed information for a specific RFID tag.          |
| <b>show location rfid summary</b>                   | Displays a list of all RFID tags currently connected to the .       |
| <b>show location rfid client</b>                    | Displays a list of RFID tags that are associated to the as clients. |

## Additional References RFID Tag Tracking

### Related Documents

| Related Topic              | Document Title                                                                               |
|----------------------------|----------------------------------------------------------------------------------------------|
| System management commands | <i>System Management Command Reference, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i> |

### Standards and RFCs

| Standard/RFC | Title |
|--------------|-------|
| None         | —     |

### MIBs

| MIB                                      | MIBs Link                                                                                                                                                                                                              |
|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| All the supported MIBs for this release. | To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:<br><a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a> |

### Technical Assistance

| Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Link                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p> | <a href="http://www.cisco.com/support">http://www.cisco.com/support</a> |

# Feature History and Information For Performing RFID Tag Tracking Configuration

| Release            | Feature Information          |
|--------------------|------------------------------|
| Cisco IOS XE 3.2SE | This feature was introduced. |



## CHAPTER 141

# Configuring Location Settings

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- [Finding Feature Information, on page 2593](#)
- [Information About Configuring Location Settings, on page 2593](#)
- [How to Configure Location Settings, on page 2594](#)
- [Monitoring Location Settings and NMSP Settings, on page 2598](#)
- [Examples: Location Settings Configuration, on page 2599](#)
- [Examples: NMSP Settings Configuration, on page 2599](#)
- [Additional References for Location Settings, on page 2599](#)
- [Feature History and Information For Performing Location Settings Configuration, on page 2600](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Configuring Location Settings

The device determines the location of client devices by gathering Received Signal Strength Indication (RSSI) measurements from access points all around the client of interest. The device can obtain location reports from up to 16 access points for clients, RFID tags, and rogue access points.

You can configure the path loss measurement (S60) request for normal clients or calibrating clients to improve location accuracy.

# How to Configure Location Settings

## Configuring Location Settings (CLI)

### Procedure

|               | Command or Action                                                                                                                                                                   | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <b>configure terminal</b>                                                                                                   | Enters global configuration mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Step 2</b> | <b>location plm {calibrating [multiband   uniband]   client burst_interval</b><br><b>Example:</b><br>Device(config)# <b>location plm client 100</b>                                 | <p>Configures the path loss measurement (S60) request for calibrating clients or non-calibrating.</p> <p>The path loss measurement request improves the location accuracy. You can configure the <b>burst_interval</b> parameter for the normal, noncalibrating client from zero through 3600 seconds, and the default value is 60 seconds.</p> <p>You can configure the path loss measurement request for calibrating clients on the associated 802.11a or 802.11b/g radio or on the associated 802.11a/b/g radio.</p> <p>If a client does not send probes often or sends them only on a few channels, its location cannot be updated or cannot be updated accurately. The <b>location plm</b> command forces clients to send more packets on all channels. When a CCXv4 (or higher) client associates, the Device sends it a path loss measurement request, which instructs the client to transmit on the bands and channels that the access points are on (typically, channels 1, 6, and 11 for 2.4-GHz-only access points) at a configurable interval (such as 60 seconds) indefinitely.</p> |
| <b>Step 3</b> | <b>location rssi-half-life {calibrating-client   client   rogue-aps   tags } seconds</b><br><b>Example:</b><br>Device(config)# <b>location rssi-half-life calibrating-client 60</b> | <p>Configures the RSSI half life for the clients, calibrating clients, RFID tags, and rogue access points.</p> <p>You can enter the <b>location rssi-half-life</b> parameter value for the clients, calibrating clients, RFID tags, and rogue access points as 0, 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, or 300 seconds, and the default value is 0 seconds.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |



|               | Command or Action                                                                                                                                                                                                  | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               |                                                                                                                                                                                                                    | <p>Some client devices transmit at reduced power immediately after changing channels, and RF is variable, so RSSI values might vary considerably from packet to packet. The <b>location rssi-half-life</b> command increases accuracy by averaging nonuniformly arriving data using a configurable forget period (or half life).</p> <p><b>Note</b> We recommend that you do not use or modify the <b>location rssi-half-life</b> command.</p>                                                                                                                                                                                                                                                                                                         |
| <b>Step 4</b> | <p><b>location expiry</b> {<b>calibrating-client</b>   <b>client</b>   <b>rogue-aps</b>   <b>tags</b> } <i>timeout</i></p> <p><b>Example:</b></p> <pre>Device(config)# location expiry calibrating-client 50</pre> | <p>Configures the RSSI timeout value for the clients, calibrating clients, RFID tags, and rogue access points.</p> <p>You can enter the RSSI timeout value for the clients, RFID tags, and rogue access points from 5 through 3600 seconds, and the default value is 5 seconds.</p> <p>For the calibrating clients, you can enter the RSSI timeout value from 0 through 3600 seconds, and the default value is 5 seconds.</p> <p>Ensuring that recent, strong RSSIs are retained by the CPU is critical to location accuracy. The <b>location expiry</b> command enables you to specify the length of time after which old RSSI averages expire.</p> <p><b>Note</b> We recommend that you do not use or modify the <b>location expiry</b> command.</p> |
| <b>Step 5</b> | <p><b>location algorithm</b> {<b>rssi-average</b>   <b>simple</b>}</p> <p><b>Example:</b></p> <pre>Device(config)# location algorithm rssi-average</pre>                                                           | <p>Configures the algorithm used to average RSSI and signal-to-noise ratio (SNR) values.</p> <p>You can enter the <b>location algorithm rssi-average</b> command to specify a more accurate algorithm but requires more CPU overhead or the <b>location algorithm simple</b> command to specify a faster algorithm that requires low CPU overhead but provides less accuracy.</p> <p><b>Note</b> We recommend that you do not use or modify the <b>location algorithm</b> command.</p>                                                                                                                                                                                                                                                                 |

|                | Command or Action                                                                                                                                                                        | Purpose                                                                                                                                                                                  |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 6</b>  | <b>location admin-tag</b> <i>string</i><br><b>Example:</b><br>Device (config) # <b>location admin-tag</b>                                                                                | Sets administrative tag or site information for the location of client devices.                                                                                                          |
| <b>Step 7</b>  | <b>location civic-location identifier</b> { <i>identifier</i>   <i>host</i> }<br><b>Example:</b><br>Device (config) # <b>location civic-location identifier host</b>                     | Specifies civic location information.<br>You can set the civic location identifier either as a string or host.                                                                           |
| <b>Step 8</b>  | <b>location custom-location identifier</b> { <i>identifier</i>   <i>host</i> }<br><b>Example:</b><br>Device (config) # <b>location custom-location identifier host</b>                   | Specifies custom location information.<br>You can set the custom location identifier either as a string or host.                                                                         |
| <b>Step 9</b>  | <b>location geo-location identifier</b> { <i>identifier</i>   <i>host</i> }<br><b>Example:</b><br>Device (config) # <b>location geo-location identifier host</b>                         | Specifies geographical location information of the client devices.<br>You can set the location identifier either as a string or host.                                                    |
| <b>Step 10</b> | <b>location prefer</b> { <i>cdp</i>   <i>lldp-med</i>   <i>static</i> } <b>weight</b> <i>priority_value</i><br><b>Example:</b><br>Device (config) # <b>location prefer weight cdp 50</b> | Sets location information source priority.<br>You can enter the priority weight from zero through 255.                                                                                   |
| <b>Step 11</b> | <b>location rfid</b> { <i>status</i>   <i>timeout</i>   <i>vendor-name</i> }<br><b>Example:</b><br>Device (config) # <b>location rfid timeout 100</b>                                    | Configures RFID tag tracking options such as RFID tag status, RFID timeout value, and RFID tag vendor name.<br>You can enter the RFID timeout value in a range from 60 and 7200 seconds. |
| <b>Step 12</b> | <b>end</b><br><b>Example:</b><br>Device (config) # <b>end</b>                                                                                                                            | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                   |

### Example

## Modifying the NMSP Notification Interval for Clients, RFID Tags, and Rogues

NMSP manages communication between the Cisco Mobility Services Engine (Cisco MSE) and the controller for incoming and outgoing traffic. If your application requires more frequent location updates, you can modify

the NMSP notification interval (to a value between 1 and 180 seconds) for clients, active RFID tags, and rogue access points and clients.



**Note** The TCP port (16113) that the controller and Cisco MSE communicate over must be open (not blocked) on any firewall that exists between the controller and the Cisco MSE for NMSP to function.

### Procedure

|               | Command or Action                                                                                                                                                                                                                                                                     | Purpose                                                                                                                                                                                                           |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <code>configure terminal</code>                                                                                                                                                                                               | Enters global configuration mode.                                                                                                                                                                                 |
| <b>Step 2</b> | <b>nmosp notification interval</b> {attachment <i>seconds</i>   location <i>seconds</i>   rssi [clients <i>interval</i>   rfid <i>interval</i>   rogues [ap   client ] <i>interval</i> ]}<br><b>Example:</b><br>Device(config)# <code>nmosp notification interval rssi rfid 50</code> | Sets the NMSP notification interval value for clients, RFID tags, and rogue clients and access points.<br><br>You can enter the NMSP notification interval value for RSSI measurement from 1 through 180 seconds. |
| <b>Step 3</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <code>end</code>                                                                                                                                                                                                                     | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                                            |

## Modifying the NMSP Notification Threshold for Clients, RFID Tags, and Rogues

### Procedure

|               | Command or Action                                                                                                                                                      | Purpose                                                                                                                                                                                 |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br>Device# <code>configure terminal</code>                                                                                | Enters global configuration mode.                                                                                                                                                       |
| <b>Step 2</b> | <b>location notify-threshold</b> {clients   rogues ap   tags } <i>threshold</i><br><b>Example:</b><br>Device(config)# <code>location notify-threshold clients 5</code> | Configures the NMSP notification threshold for clients, RFID tags, rogue clients, and access points.<br><br><i>threshold</i> - RSSI threshold value in db. Valid range is from 0 to 10. |
| <b>Step 3</b> | <b>end</b><br><b>Example:</b><br>Device(config)# <code>end</code>                                                                                                      | Returns to privileged EXEC mode.<br>Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.                                                                  |

# Monitoring Location Settings and NMSP Settings

## Monitoring Location Settings (CLI)

This section describes the new commands for location settings.

The following commands can be used to monitor location settings on the .

**Table 208: Monitoring Location Settings Commands**

| Command                                            | Purpose                                             |
|----------------------------------------------------|-----------------------------------------------------|
| <b>show location summary</b>                       | Displays the current location configuration values. |
| <b>show location statistics rfid</b>               | Displays the location-based RFID statistics.        |
| <b>show location detail <i>client_mac_addr</i></b> | Displays the RSSI table for a particular client.    |

## Monitoring NMSP Settings (CLI)

The following commands can be used to monitor NMSP settings on the .

**Table 209: Monitoring NMSP Settings Commands**

| Command                                             | Purpose                                                                                 |
|-----------------------------------------------------|-----------------------------------------------------------------------------------------|
| <b>show nmsp attachment suppress interfaces</b>     | Displays the attachment suppress interfaces.                                            |
| <b>show nmsp capability</b>                         | Displays the NMSP capabilities.                                                         |
| <b>show nmsp notification interval</b>              | Displays the NMSP notification intervals.                                               |
| <b>show nmsp statistics connection</b>              | Displays the connection-specific NMSP counters.                                         |
| <b>show nmsp statistics summary</b>                 | Displays the common NMSP counters.                                                      |
| <b>show nmsp status</b>                             | Displays the status of active NMSP connections.                                         |
| <b>show nmsp subscription detail</b>                | Displays all of the mobility services to which the is subscribed.                       |
| <b>show nmsp subscription detail <i>ip_addr</i></b> | Displays details only for the mobility services subscribed to by a specific IP address. |
| <b>show nmsp subscription summary</b>               | Displays details for all of the mobility services to which the is subscribed.           |

## Examples: Location Settings Configuration

This example shows how to configure the path loss measurement (S60) request for calibrating client on the associated 802.11a or 802.11b/g radio:

```
Device# configure terminal
Device(config)# location plm calibrating uniband
Device(config)# end
Device# show location summary
```

This example shows how to configure the RSSI half life for a rouge access point:

```
Device# configure terminal
Device(config)# location rssi-half-life rogue-aps 20
Device(config)# end
Device# show location summary
```

## Examples: NMSP Settings Configuration

This example shows how to configure the NMSP notification interval for RFID tags:

```
Device# configure terminal
Device(config)# nmsp notification interval rssi rfid 50
Device(config)# end
Device# show nmsp notification interval
```

This example shows how to configure the NMSP notification interval for clients:

```
Device# configure terminal
Device(config)# nmsp notification interval rssi clients 180
Device(config)# end
Device# show nmsp notification interval
```

## Additional References for Location Settings

### Related Documents

| Related Topic              | Document Title                                                                               |
|----------------------------|----------------------------------------------------------------------------------------------|
| System management commands | <i>System Management Command Reference, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i> |

### Standards and RFCs

| Standard/RFC | Title |
|--------------|-------|
| None         | —     |

**MIBs**

| MIB                                      | MIBs Link                                                                                                                                                                                                              |
|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| All the supported MIBs for this release. | To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:<br><a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a> |

**Technical Assistance**

| Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Link                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p> | <a href="http://www.cisco.com/support">http://www.cisco.com/support</a> |

## Feature History and Information For Performing Location Settings Configuration

| Release            | Feature Information          |
|--------------------|------------------------------|
| Cisco IOS XE 3.2SE | This feature was introduced. |



## CHAPTER 142

# Cisco Hyperlocation

- [Finding Feature Information](#), on page 2601
- [Restrictions on Cisco Hyperlocation](#), on page 2601
- [Information About Cisco Hyperlocation](#), on page 2601
- [Configuring Cisco Hyperlocation - Global Configuration \(CLI\)](#), on page 2603
- [Configuring Cisco Hyperlocation for an AP Group \(CLI\)](#), on page 2605
- [Configuring Hyperlocation BLE Beacon Parameters](#), on page 2607
- [Configuring Hyperlocation BLE Beacon Parameters for AP](#), on page 2608

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Restrictions on Cisco Hyperlocation

- FlexConnect mode is not supported.
- Only IPv4 addresses are supported for the NTP server.
- It is not possible to disable Cisco Hyperlocation on individual APs.

## Information About Cisco Hyperlocation

Cisco Hyperlocation is an ultraprecise location solution that allows you to track the location of wireless clients with the accuracy of one meter. This is possible thanks to the Cisco Hyperlocation radio module that is part of Cisco Aironet 3600 and 3700 Series Access Points. This powerful module combines Wi-Fi and Bluetooth Low Energy (BLE) technologies to allow pinpointing beacons, inventory and personal mobile devices.

The Cisco Hyperlocation radio module provides the following:

- WSM radio module functions that are extended to:

- 802.11ac
- Wi-Fi Transmit
- WSM and RRM channel scanning that is extended to 20-MHz, 40-MHz, and 80-MHz channel bandwidth.
- Expanded location functionality:
  - Low latency location optimized channel scanning
  - 32-antenna angle of arrival (AoA)

Cisco Hyperlocation works in conjunction with Cisco Connected Mobile eXperience (CMX). Combining the Cisco Hyperlocation feature on the Cisco Catalyst 3850 or 3650 Series Switch with a CMX device allows to achieve better location accuracy, which can result in delivering more targeted content to users. When you use CMX with Cisco CleanAir frequency scanning, it is simple to locate failed, lost, and even rogue beacons.

### Enhancements in Cisco IOS XE Denali 16.3.1 Release

- The Cisco Hyperlocation radio module with Integrated BLE Radio allows to transmit Bluetooth Low Energy (BLE) broadcast messages by using up to 5 BLE transmitters. The Cisco Catalyst 3850/3650 Switch is used to configure the transmission parameters such as interval for the beacons, UUID, and transmission power, per beacon globally for all the access points. Also, the Cisco Catalyst 3850/3650 Switch can configure major, minor, and transmission power value of each access point, thus providing more beacon granularity. This feature works in conjunction with Cisco Hyperlocation radio module and Hyperlocation feature.



---

**Note** Cisco Hyperlocation feature must be enabled on the APs for Hyperlocation BLE to work.

---

- The Cisco Hyperlocation feature is enhanced such that the location performance via data packets RSSI is reported through Local Mode radios through CPU cycle stealing when Cisco Hyperlocation radio module is not installed on an AP. This enhancement is available on the following APs:
  - Cisco Aironet 700 Series APs
  - Cisco Aironet 1700 Series APs
  - Cisco Aironet 2600 Series APs
  - Cisco Aironet 2700 Series APs
  - Cisco Aironet 3600 Series APs
  - Cisco Aironet 3700 Series APs
- You can configure Cisco Hyperlocation for an AP group. Previously, Cisco Hyperlocation configuration was applicable to all APs globally.

### Additional References

For more information about Cisco Hyperlocation, refer to the following documents:



- [Cisco Hyperlocation Solution](#)
- [Cisco CMX 10.2 Configuration Guide to enable Cisco Hyperlocation](#)
- [Cisco CMX 10.2 Release Notes](#)

## Configuring Cisco Hyperlocation - Global Configuration (CLI)

### Procedure

- **configure terminal**

**Example:**

```
Device# configure terminal
```

Enters global configuration mode.

- **[no] ap hyperlocation**

**Example:**

```
Device(config)# [no] ap hyperlocation
```

Enables or disables Hyperlocation on all the APs.

- **[no] ap hyperlocation threshold detection *value-in-dBm***

**Example:**

```
Device(config)# [no] ap hyperlocation threshold detection -100
```

Sets threshold to filter out packets with low RSSI. The **[no]** form of the command resets the threshold to its default value.

- **[no] ap hyperlocation threshold reset *value-btwn-0-99***

**Example:**

```
Device(config)# [no] ap hyperlocation threshold reset 8
```

Resets value in scan cycles after trigger. The **[no]** form of the command resets the threshold to its default value.

- **[no] ap hyperlocation threshold trigger *value-btwn-1-100***

**Example:**

```
Device(config)# [no] ap hyperlocation threshold trigger 10
```

Sets the number of scan cycles before sending a BAR to clients. The **[no]** form of the command resets the threshold to its default value.

- **[no] ap ntp ip *ipv4-address-of-ntp-server***

**Example:**

```
Device(config)# [no] ap ntp ip 9.0.0.4
```

Sets the IPv4 address of the NTP server, directly reachable by the access points. The **[no]** form of the command resets the NTP value to 0.0.0.0.

- **show ap hyperlocation summary**

**Example:**

```
Device# show ap hyperlocation summary

Site Name: default-group
Site Description:
Hyperlocation operational status: Up
Reason: N/A
Hyperlocation NTP server currently used: 9.0.0.4
Hyperlocation admin status: Enabled
Hyperlocation detection threshold: -100 dBm
Hyperlocation trigger threshold: 10
Hyperlocation reset threshold: 8
```

Shows the overall configuration values and operational status and parameters for default AP group.

- **show ap hyperlocation detail**

**Example:**

```
Device# show ap hyperlocation detail

Site Name: default-group
Site Description:
Hyperlocation operational status: Up
Reason: N/A
Hyperlocation NTP server currently used: 9.0.0.4
Hyperlocation admin status: Enabled
Hyperlocation detection threshold: -100 dBm
Hyperlocation trigger threshold: 10
Hyperlocation reset threshold: 8
```

Values for APs in all AP Groups:

| AP Name          | Radio MAC      | Method | Hyperlocation |
|------------------|----------------|--------|---------------|
| APf07f.0635.2d40 | f07f.0676.3b89 | WSM    | Enabled       |
| APf4cf.e272.4ed0 | f4cf.e223.ba31 | Local  | Enabled       |

Shows both overall and per-AP configuration values and operational status. The Method column of the AP rows shows “Local” for APs on Local Mode FastLocate. The values shown for Hyperlocation status and parameters reflect the values for default AP group.

- **set platform software trace wireless switch active R0 hyperlocation {debug | emergency | error | info | noise | notice | verbose | warning}**

Tracing commands that are specific to Cisco Hyperlocation:

- **debug**—Debug messages
- **emergency**—Emergency possible message
- **error**—Error messages
- **info**—Informational messages
- **noise**—Maximum possible message

- **notice**—Notice messages
- **verbose**—Verbose debug messages
- **warning**—Warning messages

## Configuring Cisco Hyperlocation for an AP Group (CLI)

### Procedure

|               | Command or Action                                                                                                                                                       | Purpose                                                                                                                                        |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure terminal</b><br><b>Example:</b><br><br>Device# <b>configure terminal</b>                                                                                   | Enters global configuration mode.                                                                                                              |
| <b>Step 2</b> | <b>ap group</b> <i>ap-group-name</i><br><b>Example:</b><br><br>Device (config)# <b>ap group my-ap-group</b>                                                             | Creates an access point group.                                                                                                                 |
| <b>Step 3</b> | <b>[no] hyperlocation</b><br><b>Example:</b><br><br>Device (config-apgroup)# <b>[no] hyperlocation</b>                                                                  | Enables or disables Hyperlocation for the AP group <i>my-ap-group</i> .                                                                        |
| <b>Step 4</b> | <b>[no] hyperlocation threshold detection</b> <i>value-in-dBm</i><br><b>Example:</b><br><br>Device (config-apgroup)# <b>[no] hyperlocation threshold detection -100</b> | Sets threshold to filter out packets with low RSSI. The <b>[no]</b> form of the command resets the threshold to its default value.             |
| <b>Step 5</b> | <b>[no] hyperlocation threshold reset</b> <i>value-btwn-0-99</i><br><b>Example:</b><br><br>Device (config-apgroup)# <b>[no] hyperlocation threshold reset 8</b>         | Resets value in scan cycles after trigger. The <b>[no]</b> form of the command resets the threshold to its default value.                      |
| <b>Step 6</b> | <b>[no] hyperlocation threshold trigger</b> <i>value-btwn-1-100</i><br><b>Example:</b><br><br>Device (config-apgroup)# <b>[no] hyperlocation threshold trigger 10</b>   | Sets the number of scan cycles before sending a BAR to clients. The <b>[no]</b> form of the command resets the threshold to its default value. |
| <b>Step 7</b> | <b>[no] ntp ip</b> <i>ipv4-address-of-ntp-server</i><br><b>Example:</b>                                                                                                 | Sets the IPv4 address of the NTP server, directly reachable by the APs of an AP group.                                                         |

|                | Command or Action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Purpose                                                                                                                                                                                        |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | Device (config-apgroup)# [no] ntp ip 9.0.0.4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | The [no] form of the command resets the NTP value to 0.0.0.0.                                                                                                                                  |
| <b>Step 8</b>  | <p><b>show ap group <i>ap-group-name</i> hyperlocation summary</b></p> <p><b>Example:</b></p> <pre>Device# show ap group my-ap-group hyperlocation summary  Site Name: my-ap-group Site Description: This is an AP group Hyperlocation operational status: Up Reason: N/A Hyperlocation NTP server currently used:  9.0.0.4 Hyperlocation admin status: Enabled Hyperlocation detection threshold: -100 dBm Hyperlocation trigger threshold: 11 Hyperlocation reset threshold: 9</pre>                                                                                                                                                                                                      | Shows the overall configuration values (AP group specific) and operational status and parameters for the AP group <i>my-ap-group</i> .                                                         |
| <b>Step 9</b>  | <p><b>show ap group <i>ap-group-name</i> hyperlocation detail</b></p> <p><b>Example:</b></p> <pre>Device# show ap group my-ap-group hyperlocation detail  Site Name: my-ap-group Site Description: This is an AP group Hyperlocation operational status: Up Reason: N/A Hyperlocation NTP server currently used:  9.0.0.4 Hyperlocation admin status: Enabled Hyperlocation detection threshold: -100 dBm Hyperlocation trigger threshold: 11 Hyperlocation reset threshold: 9  Values for APs in all AP Groups:  AP Name          Radio MAC Method    Hyperlocation ----- APf07f.0635.2d40    f07f.0676.3b89   WSM      Enabled APf4cf.e272.4ed0    f4cf.e223.ba31   Local   Enabled</pre> | Shows both overall (AP group specific) and per-AP configuration values and operational status for the AP group <i>my-ap-group</i> . The APs listed are only those that belong to the AP group. |
| <b>Step 10</b> | <p><b>show ap groups</b></p> <p><b>Example:</b></p> <pre>Device# show ap groups  Site Name: my-ap-group</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Shows Hyperlocation operational status for each AP group.                                                                                                                                      |

|  | Command or Action                                                                           | Purpose |
|--|---------------------------------------------------------------------------------------------|---------|
|  | Site Description: This is an AP group<br>...<br>Hyperlocation operational status: Up<br>... |         |

## Configuring Hyperlocation BLE Beacon Parameters

To configure hyperlocation BLE beacon parameters, use the procedure given below:

### Procedure

- 
- Step 1**     **configure terminal**
- Example:**
- ```
Controller# configure terminal
```
- Enters the global configuration mode.
- Step 2**     **ap hyperlocation ble-beacon** *{ beacon-id | interval interval-value }*
- Example:**
- ```
Controller(config)# ap hyperlocation ble-beacon 3
```
- Specifies the BLE beacon parameters and enters the BLE configuration mode.
- Step 3**     **config-ble** *{ default { enable | txpwr | uuid } | enable | exit | no { enable | txpwr | uuid } | txpwr att-value | uuid uuid-name }*
- Example:**
- ```
Controller(config-ble)# enable
```
- Configures the BLE beacon values.
- Step 4**     **show ap hyperlocation ble-beacon**
- Example:**
- ```
Controller# show ap hyperlocation ble-beacon
```
- ```
BLE Beacon interval (Hertz): 1
```
- ```
ID UUID          TX Power(dBm) Status
-----
```
- ```
0 00000000-0000-0000-0000-000000000000 -34 Disabled
1 00000000-0000-0000-0000-000000000000 0 Disabled
2 00000000-0000-0000-0000-000000000000 0 Disabled
3 00000000-0000-0000-0000-000000000000 0 Disabled
4 00000000-0000-0000-0000-000000000000 0 Disabled
```
- Shows the list of configured BLE beacons.
-

# Configuring Hyperlocation BLE Beacon Parameters for AP

To configure hyperlocation BLE beacon parameters for an AP, use the procedure given below:

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>ap name</b> <i>ap-name</i> <b>hyperlocation ble-beacon</b> <i>beacon-id</i> { <b>major</b> <i>major-value</i>   <b>minor</b> <i>minor-value</i>   <b>txpwr</b> <i>att-value</i> }</p> <p><b>Example:</b></p> <pre>Controller# ap name test-ap hyperlocation ble-beacon 3 major 65535</pre>	Configures Hyperlocation and related parameters for an AP.
<b>Step 2</b>	<p><b>show ap name</b> <i>ap-name</i> <b>hyperlocation ble-beacon</b></p> <p><b>Example:</b></p> <pre>Controller# show ap name test-ap hyperlocation ble-beacon</pre> <pre>ID Major Minor TX Power (dBm) ----- 0 0 0 0 1 0 0 0 2 0 0 0 3 0 0 0</pre>	Shows the list of configured BLE beacons.



## CHAPTER 143

# Monitoring Flow Control

- [Finding Feature Information, on page 2609](#)
- [Information About Flow Control, on page 2609](#)
- [Monitoring Flow Control, on page 2609](#)
- [Examples: Monitoring Flow Control, on page 2610](#)
- [Additional References for Monitoring Flow Control, on page 2611](#)
- [Feature History and Information For Monitoring Flow Control, on page 2611](#)

## Finding Feature Information

Your software release may not support all of the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Flow Control

Flow control is enabled by default on the device.

Flow control provides shim layers between WCM and Cisco IOS for a reliable IPC. Every component in WCM has a dedicated channel. Few of the components in WCM have leveraged flow control in that. There is no configuration of flow control from CLI. You can monitor the flow control for any channel.

## Monitoring Flow Control

This section describes the new commands for flow control.

The following commands can be used to monitor flow control on the device.

*Table 210: Monitoring Flow Control*

Command	Purpose
---------	---------

<code>show wireless flow-control channel -id</code>	Displays information about flow control on a particular channel.
<code>show wireless flow-control channel-id statistics</code>	Displays statistical information about flow control on a particular channel.

## Examples: Monitoring Flow Control

This example shows how to view information pertaining to any channel:

```
Device# show wireless flow-control 3
Device#

Channel Name       : CAPWAP
FC State           : Disabled
Remote Server State : Enabled
Pass-thru Mode     : Disabled
EnQ Disabled       : Disabled
Queue Depth        : 2048
Max Retries        : 5
Min Retry Gap (mSec) : 3
```

This example shows how to view flow control for a particular channel:

```
Device# show wireless flow-control 3
Device#

Channel Name                : CAPWAP
# of times channel went into FC : 0
# of times channel came out of FC : 0
Total msg count received by the FC Infra : 1
Pass-thru msgs send count      : 0
Pass-thru msgs fail count      : 0
# of msgs successfully queued   : 0
# of msgs for which queuing failed : 0
# of msgs sent thru after queuing : 0
# of msgs sent w/o queuing      : 1
# of msgs for which send failed  : 0
# of invalid EAGAINS received   : 0
Highest watermark reached       : 0
# of times Q hit max capacity    : 0
Avg time channel stays in FC (mSec) : 0
```



## Additional References for Monitoring Flow Control

### Related Documents

Related Topic	Document Title
System management commands	<i>System Management Command Reference Guide, Cisco IOS XE Release 3SE (Cisco WLC 5700 Series)</i>

### Standards and RFCs

Standard/RFC	Title
None	—

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information For Monitoring Flow Control

Release	Feature Information
Cisco IOS XE 3.3SE	This feature was introduced.





## CHAPTER 144

# Configuring SDM Templates

- [Finding Feature Information, on page 2613](#)
- [Information About Configuring SDM Templates, on page 2613](#)
- [How to Configure SDM Templates, on page 2615](#)
- [Monitoring and Maintaining SDM Templates, on page 2616](#)
- [Configuration Examples for SDM Templates, on page 2616](#)
- [Additional References for SDM Templates, on page 2618](#)
- [Feature History and Information for Configuring SDM Templates, on page 2619](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

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## Information About Configuring SDM Templates

### SDM Templates

You can use SDM templates to configure system resources to optimize support for specific features, depending on how your device is used in the network. You can select a template to provide maximum system usage for some functions.

These templates are supported on your device:

- **Advanced**—The advanced template is available on all supported images for this release. It maximizes system resources for features like netflow, multicast groups, security ACEs, QoS ACEs, and so on.
- **VLAN**—The VLAN template is available only on the LAN Base license. The VLAN template disables routing and supports the maximum number of unicast MAC addresses. It would typically be selected for a Layer 2 device.

After you change the template and the system reboots, you can use the **show sdm prefer** privileged EXEC command to verify the new template configuration. If you enter the **show sdm prefer** command before you enter the **reload** privileged EXEC command, the **show sdm prefer** command shows the template currently in use and the template that will become active after a reload.

The default is the advanced template.

**Table 211: Approximate Number of Feature Resources Allowed by Templates**

Resource	Advanced	VLAN
Number of VLANs	4094	4094
Unicast MAC addresses	32 K	32 K
Overflow unicast MAC addresses	512	512
IGMP groups and multicast routes	4 K	4 K
Overflow IGMP groups and multicast routes	512	512
• Directly connected routes	16K	16 K
• Indirectly connected IP hosts	7 K	7 K
Policy-based routing ACEs	1024	0
QoS classification ACEs	3 K	3 K
Security ACEs	3 K	3 K
Netflow ACEs	1024	1024
Input Microflow policer ACEs:	256 K	0
Output Microflow policer ACEs:	256 K	0
FSPAN ACEs	256	256
Control Plane Entries:	512	512
Input Netflow flows:	8 K	8 K
Output Netflow flows:	16 K	16 K



**Note** When the switch is used as a Wireless Mobility Agent, the only template allowed is the advanced template.



**Note** SDM templates do not create VLANs. You must create the VLANs before adding commands to the SDM templates.

The tables represent approximate hardware boundaries set when a template is selected. If a section of a hardware resource is full, all processing overflow is sent to the CPU, seriously impacting switch performance.

## SDM Templates and Switch Stacks

In a switch stack, all stack members must use the same SDM template that is stored on the active switch. When a new switch is added to a stack, the SDM configuration that is stored on the active switch overrides the template configured on an individual switch.

You can use the **show switch** privileged EXEC command to see if any stack members are in SDM mismatch mode.

# How to Configure SDM Templates

## Configuring SDM Templates

### Configuring the Switch SDM Template

#### Setting the SDM Template

Follow these steps to use the SDM template to maximize feature usage:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>sdm prefer { advanced   vlan }</b> <b>Example:</b> Device(config)# <b>sdm prefer advanced</b>	Specifies the SDM template to be used on the switch. The keywords have these meanings: <ul style="list-style-type: none"> <li>• <b>advanced</b> —Supports advanced features such as Netflow.</li> <li>• <b>vlan</b> —Maximizes VLAN configuration on the switch with no routing supported in hardware.</li> </ul> <p><b>Note</b> The <b>no sdm prefer</b> command and a default template is not supported.</p>

	Command or Action	Purpose
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>reload</b> <b>Example:</b> Device # <b>reload</b>	Reloads the operating system.

## Monitoring and Maintaining SDM Templates

Command	Purpose
show sdm prefer	Displays the SDM template in use.
reload	Reloads the switch to activate the newly configured SDM template.
no sdm prefer	Sets the default SDM template.



**Note** The SDM templates contain only those commands that are defined as part of the templates. If a template enables another related command that is not defined in the template, then this other command will be visible when the **show running config** command is entered. For example, if the SDM template enables the **switchport voice vlan** command, then the **spanning-tree portfast edge** command may also be enabled (although it is not defined on the SDM template).

If the SDM template is removed, then other such related commands are also removed and have to be reconfigured explicitly.

## Configuration Examples for SDM Templates

### Examples: Configuring SDM Templates

This example shows how to configure the VLAN template:

```
Device(config) # sdm prefer vlan
Device(config) # exit
Device# reload
Proceed with reload? [confirm]
```

## Examples: Displaying SDM Templates

This is an example output showing the advanced template information:

```
Device# show sdm prefer

Showing SDM Template Info

This is the Advanced template.
Number of VLANs: 4094
Unicast MAC addresses: 32768
Overflow Unicast MAC addresses: 512
IGMP and Multicast groups: 8192
Overflow IGMP and Multicast groups: 512
Directly connected routes: 32768
Indirect routes: 8192
Security Access Control Entries: 3072
QoS Access Control Entries: 2816
Policy Based Routing ACEs: 1024
Netflow ACEs: 1024
Input Microflow policer ACEs: 256
Output Microflow policer ACEs: 256
Flow SPAN ACEs: 256
Tunnels: 256
Control Plane Entries: 512
Input Netflow flows: 8192
Output Netflow flows: 16384
These numbers are typical for L2 and IPv4 features.
Some features such as IPv6, use up double the entry size;
so only half as many entries can be created.
```

This is an example output showing the VLAN template information:

```
Device# show sdm prefer vlan

Showing SDM Template Info

This is the VLAN template for a typical Layer 2 network.
Number of VLANs: 4094
Unicast MAC addresses: 32768
Overflow Unicast MAC addresses: 512
IGMP and Multicast groups: 8192
Overflow IGMP and Multicast groups: 512
Directly connected routes: 32768
Indirect routes: 8192
Security Access Control Entries: 3072
QoS Access Control Entries: 3072
Policy Based Routing ACEs: 0
Netflow ACEs: 1024
Input Microflow policer ACEs: 0
Output Microflow policer ACEs: 0
Flow SPAN ACEs: 256
Tunnels: 0
Control Plane Entries: 512
Input Netflow flows: 16384
Output Netflow flows: 8192
```

These numbers are typical for L2 and IPv4 features.  
Some features such as IPv6, use up double the entry size;  
so only half as many entries can be created.

## Additional References for SDM Templates

### Related Documents

Related Topic	Document Title
Command Reference	<i>System Management Command Reference (Catalyst 3850 Switches)</i>
VLAN Configuration Guide	<i>VLAN Configuration Guide (Catalyst 3850 Switches)</i>

### Standards and RFCs

Standard/RFC	Title
None	—

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>



## Feature History and Information for Configuring SDM Templates

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.





## CHAPTER 145

# Configuring System Message Logs

- [Finding Feature Information, on page 2621](#)
- [Information About Configuring System Message Logs, on page 2621](#)
- [How to Configure System Message Logs, on page 2624](#)
- [Monitoring and Maintaining System Message Logs, on page 2632](#)
- [Configuration Examples for System Message Logs, on page 2632](#)
- [Additional References for System Message Logs, on page 2633](#)
- [Feature History and Information For System Message Logs, on page 2634](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

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## Information About Configuring System Message Logs

### System Message Logging

By default, a switch sends the output from system messages and **debug** privileged EXEC commands to a logging process. . The logging process controls the distribution of logging messages to various destinations, such as the logging buffer, terminal lines, or a UNIX syslog server, depending on your configuration. The process also sends messages to the console.

When the logging process is disabled, messages are sent only to the console. The messages are sent as they are generated, so message and debug output are interspersed with prompts or output from other commands. Messages appear on the active consoles after the process that generated them has finished.

You can set the severity level of the messages to control the type of messages displayed on the consoles and each of the destinations. You can time-stamp log messages or set the syslog source address to enhance real-time

debugging and management. For information on possible messages, see the system message guide for this release.

You can access logged system messages by using the switch command-line interface (CLI) or by saving them to a properly configured syslog server. The switch software saves syslog messages in an internal buffer on a standalone switch. If a standalone switch, the log is lost unless you had saved it to flash memory.

You can remotely monitor system messages by viewing the logs on a syslog server or by accessing the switch through Telnet, through the console port, or through the Ethernet management port.



**Note** The syslog format is compatible with 4.3 BSD UNIX.

## System Log Message Format

System log messages can contain up to 80 characters and a percent sign (%), which follows the optional sequence number or time-stamp information, if configured. Depending on the switch, messages appear in one of these formats:

- *seq no:timestamp: %facility-severity-MNEMONIC:description (hostname-n)*
- *seq no:timestamp: %facility-severity-MNEMONIC:description*

The part of the message preceding the percent sign depends on the setting of these global configuration commands:

- **service sequence-numbers**
- **service timestamps log datetime**
- **service timestamps log datetime [localtime] [msec] [show-timezone]**
- **service timestamps log uptime**

**Table 212: System Log Message Elements**

Element	Description
<i>seq no:</i>	Stamps log messages with a sequence number only if the <b>service sequence-numbers</b> global configuration command is configured.
<i>timestamp</i> formats: <i>mm/dd h h:mm:ss</i> or <i>hh:mm:ss</i> (short uptime) or <i>d h</i> (long uptime)	Date and time of the message or event. This information appears only if the <b>service timestamps log [datetime   log]</b> global configuration command is configured.
<i>facility</i>	The facility to which the message refers (for example, SNMP, SYS, and so forth).

Element	Description
<i>severity</i>	Single-digit code from 0 to 7 that is the severity of the message.
<i>MNEMONIC</i>	Text string that uniquely describes the message.
<i>description</i>	Text string containing detailed information about the event being reported.
<i>hostname-n</i>	Hostname of a stack member and its switch number in the stack. Though the active switch is a stack member, it does <i>not</i> append its hostname to system messages.

## Default System Message Logging Settings

Table 213: Default System Message Logging Settings

Feature	Default Setting
System message logging to the console	Enabled.
Console severity	Debugging.
Logging file configuration	No filename specified.
Logging buffer size	4096 bytes. <sup>32</sup>
Logging history size	1 message.
Time stamps	Disabled.
Synchronous logging	Disabled.
Logging server	Disabled.
Syslog server IP address	None configured.
Server facility	Local7
Server severity	Informational.

<sup>32</sup> For Cisco IOS XE 3.6E release, the default logging buffer size is 16384 bytes.

## Syslog Message Limits

If you enabled syslog message traps to be sent to an SNMP network management station by using the **snmp-server enable trap** global configuration command, you can change the level of messages sent and stored in the switch history table. You also can change the number of messages that are stored in the history table.

Messages are stored in the history table because SNMP traps are not guaranteed to reach their destination. By default, one message of the level **warning** and numerically lower levels are stored in the history table even if syslog traps are not enabled.

When the history table is full (it contains the maximum number of message entries specified with the **logging history size** global configuration command), the oldest message entry is deleted from the table to allow the new message entry to be stored.

The history table lists the level keywords and severity level. For SNMP usage, the severity level values increase by 1. For example, *emergencies* equal 1, not 0, and *critical* equals 3, not 2.

## How to Configure System Message Logs

### Setting the Message Display Destination Device

If message logging is enabled, you can send messages to specific locations in addition to the console.

This task is optional.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>logging buffered [size]</b> <b>Example:</b> Device(config)# <b>logging buffered 8192</b>	Logs messages to an internal buffer on the switch or on a standalone switch or, in the case of a switch stack, on the active switch. The range is 4096 to 2147483647 bytes. The default buffer size is 4096 bytes.  If a standalone switch or the active switch fails, the log file is lost unless you previously saved it to flash memory. See Step 4.  <b>Note</b> Do not make the buffer size too large because the switch could run out of memory for other tasks. Use the <b>show memory</b> privileged EXEC command to view the free processor memory on the switch. However, this value is the maximum available, and the buffer size should <i>not</i> be set to this amount.
<b>Step 3</b>	<b>logging host</b> <b>Example:</b> Device(config)# <b>logging 125.1.1.100</b>	Logs messages to a UNIX syslog server host.  <i>host</i> specifies the name or IP address of the host to be used as the syslog server.

	Command or Action	Purpose
		To build a list of syslog servers that receive logging messages, enter this command more than once.
<b>Step 4</b>	<p><b>logging file flash:</b> <i>filename</i> [<i>max-file-size</i> [<i>min-file-size</i>]] [<i>severity-level-number</i>   <i>type</i>]</p> <p><b>Example:</b></p> <pre>Device(config)# logging file flash:log_msg.txt 40960 4096 3</pre>	<p>Stores log messages in a file in flash memory on a standalone switch or, in the case of a switch stack, on the active switch.</p> <ul style="list-style-type: none"> <li>• <i>filename</i>—Enters the log message filename.</li> <li>• (Optional) <b>max-file-size</b> —Specifies the maximum logging file size. The range is 4096 to 2147483647. The default is 4096 bytes.</li> <li>• (Optional) <i>min-file-size</i>—Specifies the minimum logging file size. The range is 1024 to 2147483647. The default is 2048 bytes.</li> <li>• (Optional) <i>severity-level-number</i>   <i>type</i>—Specifies either the logging severity level or the logging type. The severity range is 0 to 7.</li> </ul>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<p><b>terminal monitor</b></p> <p><b>Example:</b></p> <pre>Device# terminal monitor</pre>	<p>Logs messages to a nonconsole terminal during the current session.</p> <p>Terminal parameter-setting commands are set locally and do not remain in effect after the session has ended. You must perform this step for each session to see the debugging messages.</p>

## Synchronizing Log Messages

You can synchronize unsolicited messages and **debug** privileged EXEC command output with solicited device output and prompts for a specific console port line or virtual terminal line. You can identify the types of messages to be output asynchronously based on the level of severity. You can also configure the maximum number of buffers for storing asynchronous messages for the terminal after which messages are dropped.

When synchronous logging of unsolicited messages and **debug** command output is enabled, unsolicited device output appears on the console or printed after solicited device output appears or is printed. Unsolicited messages and **debug** command output appears on the console after the prompt for user input is returned. Therefore,

unsolicited messages and **debug** command output are not interspersed with solicited device output and prompts. After the unsolicited messages appear, the console again displays the user prompt.

This task is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>line [console   vty] line-number</b> <b>[ending-line-number]</b> <b>Example:</b> Device(config)# <b>line console</b>	Specifies the line to be configured for synchronous logging of messages. <ul style="list-style-type: none"> <li>• <b>console</b>—Specifies configurations that occur through the switch console port or the Ethernet management port.</li> <li>• <b>line vty line-number</b>—Specifies which vty lines are to have synchronous logging enabled. You use a vty connection for configurations that occur through a Telnet session. The range of line numbers is from 0 to 15.</li> </ul> <p>You can change the setting of all 16 vty lines at once by entering:</p> <pre>line vty 0 15</pre> <p>You can also change the setting of the single vty line being used for your current connection. For example, to change the setting for vty line 2, enter:</p> <pre>line vty 2</pre> <p>When you enter this command, the mode changes to line configuration.</p>
<b>Step 3</b>	<b>logging synchronous [level [severity-level   all]   limit number-of-buffers]</b> <b>Example:</b> Device(config)# <b>logging synchronous level 3 limit 1000</b>	Enables synchronous logging of messages. <ul style="list-style-type: none"> <li>• (Optional) <b>level severity-level</b>—Specifies the message severity level. Messages with a severity level equal to or higher than this value are printed asynchronously. Low numbers mean greater severity and high numbers mean lesser severity. The default is 2.</li> </ul>



	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• (Optional) <b>level all</b>—Specifies that all messages are printed asynchronously regardless of the severity level.</li> <li>• (Optional) <b>limit number-of-buffers</b>—Specifies the number of buffers to be queued for the terminal after which new messages are dropped. The range is 0 to 2147483647. The default is 20.</li> </ul>
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Disabling Message Logging

Message logging is enabled by default. It must be enabled to send messages to any destination other than the console. When enabled, log messages are sent to a logging process, which logs messages to designated locations asynchronously to the processes that generated the messages.

Disabling the logging process can slow down the switch because a process must wait until the messages are written to the console before continuing. When the logging process is disabled, messages appear on the console as soon as they are produced, often appearing in the middle of command output.

The **logging synchronous** global configuration command also affects the display of messages to the console. When this command is enabled, messages appear only after you press **Return**.

To reenable message logging after it has been disabled, use the **logging on** global configuration command.

This task is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>no logging console</b> <b>Example:</b> Device(config)# <b>no logging console</b>	Disables message logging.

	Command or Action	Purpose
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.

## Enabling and Disabling Time Stamps on Log Messages

By default, log messages are not time-stamped.

This task is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	Use one of these commands: <ul style="list-style-type: none"> <li>• <b>service timestamps log uptime</b></li> <li>• <b>service timestamps log datetime[msec   localtime   show-timezone]</b></li> </ul> <b>Example:</b> Device (config) # <b>service timestamps log uptime</b> or Device (config) # <b>service timestamps log datetime</b>	Enables log time stamps. <ul style="list-style-type: none"> <li>• <b>log uptime</b>—Enables time stamps on log messages, showing the time since the system was rebooted.</li> <li>• <b>log datetime</b>—Enables time stamps on log messages. Depending on the options selected, the time stamp can include the date, time in milliseconds relative to the local time zone, and the time zone name.</li> </ul>
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.

## Enabling and Disabling Sequence Numbers in Log Messages

If there is more than one log message with the same time stamp, you can display messages with sequence numbers to view these messages. By default, sequence numbers in log messages are not displayed.

This task is optional.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>service sequence-numbers</b> <b>Example:</b> Device (config) # <b>service sequence-numbers</b>	Enables sequence numbers.
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.

## Defining the Message Severity Level

Limit messages displayed to the selected device by specifying the severity level of the message.

This task is optional.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>logging console <i>level</i></b> <b>Example:</b> Device (config) # <b>logging console 3</b>	Limits messages logged to the console. By default, the console receives debugging messages and numerically lower levels.
<b>Step 3</b>	<b>logging monitor <i>level</i></b> <b>Example:</b> Device (config) # <b>logging monitor 3</b>	Limits messages logged to the terminal lines. By default, the terminal receives debugging messages and numerically lower levels.

	Command or Action	Purpose
<b>Step 4</b>	<b>logging trap</b> <i>level</i> <b>Example:</b> Device(config)# <b>logging trap 3</b>	Limits messages logged to the syslog servers. By default, syslog servers receive informational messages and numerically lower levels.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Limiting Syslog Messages Sent to the History Table and to SNMP

This task explains how to limit syslog messages that are sent to the history table and to SNMP.

This task is optional.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>logging history</b> <i>level</i> <b>Example:</b> Device(config)# <b>logging history 3</b>	Changes the default level of syslog messages stored in the history file and sent to the SNMP server. By default, <b>warnings</b> , <b>errors</b> , <b>critical</b> , <b>alerts</b> , and <b>emergencies</b> messages are sent.
<b>Step 3</b>	<b>logging history size</b> <i>number</i> <b>Example:</b> Device(config)# <b>logging history size 200</b>	Specifies the number of syslog messages that can be stored in the history table. The default is to store one message. The range is 0 to 500 messages.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

## Logging Messages to a UNIX Syslog Daemon

This task is optional.



**Note** Some recent versions of UNIX syslog daemons no longer accept by default syslog packets from the network. If this is the case with your system, use the UNIX **man syslogd** command to decide what options must be added to or removed from the syslog command line to enable logging of remote syslog messages.

### Before you begin

- Log in as root.
- Before you can send system log messages to a UNIX syslog server, you must configure the syslog daemon on a UNIX server.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	Add a line to the file <code>/etc/syslog.conf</code> . <b>Example:</b> <pre>local7.debug /usr/adm/logs/cisco.log</pre>	<ul style="list-style-type: none"> <li>• <b>local7</b>—Specifies the logging facility.</li> <li>• <b>debug</b>—Specifies the syslog level. The file must already exist, and the syslog daemon must have permission to write to it.</li> </ul>
<b>Step 2</b>	Enter these commands at the UNIX shell prompt. <b>Example:</b> <pre>\$ touch /var/log/cisco.log \$ chmod 666 /var/log/cisco.log</pre>	Creates the log file. The syslog daemon sends messages at this level or at a more severe level to this file.
<b>Step 3</b>	Make sure the syslog daemon reads the new changes. <b>Example:</b> <pre>\$ kill -HUP `cat /etc/syslog.pid`</pre>	For more information, see the <b>man syslog.conf</b> and <b>man syslogd</b> commands on your UNIX system.

# Monitoring and Maintaining System Message Logs

## Monitoring Configuration Archive Logs

Command	Purpose
<code>show archive log config {all   number [end-number]   user username [session number] number [end-number]   statistics} [provisioning]</code>	Displays the entire configuration log or the log for specified parameters.

## Configuration Examples for System Message Logs

### Example: Stacking System Message

This example shows a partial switch system message for active switch and a stack member (hostname *Switch-2*):

```
00:00:46: %LINK-3-UPDOWN: Interface Port-channell1, changed state to up
00:00:47: %LINK-3-UPDOWN: Interface GigabitEthernet1/0/1, changed state to up
00:00:47: %LINK-3-UPDOWN: Interface GigabitEthernet1/0/2, changed state to up
00:00:48: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed state to down
00:00:48: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet1/0/1, changed
state to down 2
*Mar  1 18:46:11: %SYS-5-CONFIG_I: Configured from console by vty2 (10.34.195.36)
18:47:02: %SYS-5-CONFIG_I: Configured from console by vty2 (10.34.195.36)
*Mar  1 18:48:50.483 UTC: %SYS-5-CONFIG_I: Configured from console by vty2 (10.34.195.36)

00:00:46: %LINK-3-UPDOWN: Interface Port-channell1, changed state to up (Switch-2)
00:00:47: %LINK-3-UPDOWN: Interface GigabitEthernet2/0/1, changed state to up (Switch-2)
00:00:47: %LINK-3-UPDOWN: Interface GigabitEthernet2/0/2, changed state to up (Switch-2)
00:00:48: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed state to down
(Switch-2)
00:00:48: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet2/0/1, changed
state to down 2 (Switch-2)
```

### Example: Switch System Message

This example shows a partial switch system message on a switch:

```
00:00:46: %LINK-3-UPDOWN: Interface Port-channell1, changed state to up
00:00:47: %LINK-3-UPDOWN: Interface GigabitEthernet0/1, changed state to up
00:00:47: %LINK-3-UPDOWN: Interface GigabitEthernet0/2, changed state to up
00:00:48: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed state to down
00:00:48: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed state
to down 2
*Mar  1 18:46:11: %SYS-5-CONFIG_I: Configured from console by vty2 (10.34.195.36)
18:47:02: %SYS-5-CONFIG_I: Configured from console by vty2 (10.34.195.36)
```

```
*Mar 1 18:48:50.483 UTC: %SYS-5-CONFIG_I: Configured from console by vty2 (10.34.195.36)
```

## Additional References for System Message Logs

### Related Documents

Related Topic	Document Title
System management commands	<i>System Management Command Reference (Catalyst 3850 Switches)</i>
Platform-independent command references	<i>Configuration Fundamentals Command Reference, Cisco IOS XE Release 3S (Catalyst 3850 Switches)</i>
Platform-independent configuration information	<i>Configuration Fundamentals Configuration Guide, Cisco IOS XE Release 3S (Catalyst 3850 Switches)</i>  <i>IP Addressing Configuration Guide Library, Cisco IOS XE Release 3S (Catalyst 3850 Switches)</i>

### Standards and RFCs

Standard/RFC	Title
None	—

### MIBs

MIB	MIBs Link
All supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

**Feature History and Information For System Message Logs**

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.





## CHAPTER 146

# Configuring Online Diagnostics

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- [Information About Configuring Online Diagnostics, on page 2635](#)
- [How to Configure Online Diagnostics, on page 2636](#)
- [Monitoring and Maintaining Online Diagnostics, on page 2641](#)
- [Configuration Examples for Online Diagnostic Tests, on page 2641](#)
- [Additional References for Online Diagnostics, on page 2643](#)
- [Feature History and Information for Configuring Online Diagnostics, on page 2644](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Configuring Online Diagnostics

### Online Diagnostics

With online diagnostics, you can test and verify the hardware functionality of the Device while the Device is connected to a live network.

The online diagnostics contain packet switching tests that check different hardware components and verify the data path and the control signals.

The online diagnostics detect problems in these areas:

- Hardware components
- Interfaces (Ethernet ports and so forth)
- Solder joints

Online diagnostics are categorized as on-demand, scheduled, or health-monitoring diagnostics. On-demand diagnostics run from the CLI; scheduled diagnostics run at user-designated intervals or at specified times when the Device is connected to a live network; and health-monitoring runs in the background with user-defined intervals. By default, the health-monitoring test runs for every 30 seconds.

After you configure online diagnostics, you can manually start diagnostic tests or display the test results. You can also see which tests are configured for the Device or switch stack and the diagnostic tests that have already run.

## How to Configure Online Diagnostics

### Starting Online Diagnostic Tests

After you configure diagnostic tests to run on the Device, use the **diagnostic start** privileged EXEC command to begin diagnostic testing.

After starting the tests, you cannot stop the testing process.

Use this privileged EXEC command to manually start online diagnostic testing:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>diagnostic start switch <i>number</i> test {<i>name</i>   <i>test-id</i>   <i>test-id-range</i>   <b>all</b>   <b>basic</b>   <b>complete</b>   <b>minimal</b>   <b>non-disruptive</b>   <b>per-port</b>}</b></p> <p><b>Example:</b></p> <pre>Device# diagnostic start switch 2 test basic</pre>	<p>Starts the diagnostic tests.</p> <p>The <b>switch <i>number</i></b> keyword is supported only on stacking Device.</p> <p>You can specify the tests by using one of these options:</p> <ul style="list-style-type: none"> <li>• <b><i>name</i></b>—Enters the name of the test.</li> <li>• <b><i>test-id</i></b>—Enters the ID number of the test.</li> <li>• <b><i>test-id-range</i></b>—Enters the range of test IDs by using integers separated by a comma and a hyphen.</li> <li>• <b><i>all</i></b>—Starts all of the tests.</li> <li>• <b><i>basic</i></b>— Starts the basic test suite.</li> <li>• <b><i>complete</i></b>—Starts the complete test suite.</li> <li>• <b><i>minimal</i></b>—Starts the minimal bootup test suite.</li> <li>• <b><i>non-disruptive</i></b>—Starts the non-disruptive test suite.</li> <li>• <b><i>per-port</i></b>—Starts the per-port test suite.</li> </ul>

## Configuring Online Diagnostics

You must configure the failure threshold and the interval between tests before enabling diagnostic monitoring.

## Scheduling Online Diagnostics

You can schedule online diagnostics to run at a designated time of day or on a daily, weekly, or monthly basis for a Device. Use the **no** form of this command to remove the scheduling.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<p><b>diagnostic schedule switch number test</b> {<i>name</i>   <i>test-id</i>   <i>test-id-range</i>   <b>all</b>   <b>basic</b>   <b>complete</b>   <b>minimal</b>   <b>non-disruptive</b>   <b>per-port</b>} {<b>daily</b>   <b>on</b> <i>mm dd yyyy hh:mm</i>   <b>port</b> <i>inter-port-number</i> <i>port-number-list</i>   <b>weekly</b> <i>day-of-week hh:mm</i>}</p> <p><b>Example:</b></p> <pre>Device(config)# diagnostic schedule switch 3 test 1-5 on July 3 2013 23:10</pre>	<p>Schedules on-demand diagnostic tests for a specific day and time.</p> <p>The <b>switch number</b> keyword is supported only on stacking switches. The range is from 1 to 4.</p> <p>When specifying the tests to be scheduled, use these options:</p> <ul style="list-style-type: none"> <li>• <b>name</b>—Name of the test that appears in the <b>show diagnostic content</b> command output.</li> <li>• <b>test-id</b>—ID number of the test that appears in the <b>show diagnostic content</b> command output.</li> <li>• <b>test-id-range</b>—ID numbers of the tests that appear in the <b>show diagnostic content</b> command output.</li> <li>• <b>all</b>—All test IDs.</li> <li>• <b>basic</b>—Starts the basic on-demand diagnostic tests.</li> <li>• <b>complete</b>—Starts the complete test suite.</li> <li>• <b>minimal</b>—Starts the minimal bootup test suite.</li> <li>• <b>non-disruptive</b>—Starts the non-disruptive test suite.</li> <li>• <b>per-port</b>—Starts the per-port test suite.</li> </ul>

	Command or Action	Purpose
		<p>You can schedule the tests as follows:</p> <ul style="list-style-type: none"> <li>• Daily—Use the <b>daily</b> <i>hh:mm</i> parameter.</li> <li>• Specific day and time—Use the <b>on</b> <i>mm dd yyyy hh:mm</i> parameter.</li> <li>• Weekly—Use the <b>weekly</b> <i>day-of-week hh:mm</i> parameter.</li> </ul>

## Configuring Health-Monitoring Diagnostics

You can configure health-monitoring diagnostic testing on a Device while it is connected to a live network. You can configure the execution interval for each health-monitoring test, enable the Device to generate a syslog message because of a test failure, and enable a specific test.

Use the **no** form of this command to disable testing.

By default, health monitoring is disabled, but the Device generates a syslog message when a test fails.

Follow these steps to configure and enable the health-monitoring diagnostic tests:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	<p>Enters global configuration mode.</p>
<b>Step 3</b>	<p><b>diagnostic monitor interval switch</b> <i>number</i> <b>test</b> {<i>name</i>   <i>test-id</i>   <i>test-id-range</i>   <b>all</b>} <i>hh:mm:ss milliseconds day</i></p> <p><b>Example:</b></p> <pre>Device(config)# diagnostic monitor interval switch 2 test 1 12:30:00 750 5</pre>	<p>Configures the health-monitoring interval of the specified tests.</p> <p>The <b>switch</b> <i>number</i> keyword is supported only on stacking switches. The range is from 1 to 9.</p> <p>When specifying the tests, use one of these parameters:</p> <ul style="list-style-type: none"> <li>• <i>name</i>—Name of the test that appears in the <b>show diagnostic content</b> command output.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <i>test-id</i>—ID number of the test that appears in the <b>show diagnostic content</b> command output.</li> <li>• <i>test-id-range</i>—ID numbers of the tests that appear in the <b>show diagnostic content</b> command output.</li> <li>• <b>all</b>—All of the diagnostic tests.</li> </ul> <p>When specifying the interval, set these parameters:</p> <ul style="list-style-type: none"> <li>• <i>hh:mm:ss</i>—Monitoring interval in hours, minutes, and seconds. The range for <i>hh</i> is 0 to 24, and the range for <i>mm</i> and <i>ss</i> is 0 to 60.</li> <li>• <i>milliseconds</i>—Monitoring interval in milliseconds (ms). The range is from 0 to 999.</li> <li>• <i>day</i>—Monitoring interval in the number of days. The range is from 0 to 20.</li> </ul>
<b>Step 4</b>	<b>diagnostic monitor syslog</b> <b>Example:</b> <pre>Device(config)# diagnostic monitor syslog</pre>	(Optional) Configures the switch to generate a syslog message when a health-monitoring test fails.
<b>Step 5</b>	<b>diagnostic monitor threshold switch <i>number</i>  <i>number</i> test {<i>name</i>   <i>test-id</i>   <i>test-id-range</i>   <b>all</b>}  failure count <i>count</i></b> <b>Example:</b> <pre>Device(config)# diagnostic monitor  threshold switch 2 test 1 failure count  20</pre>	(Optional) Sets the failure threshold for the health-monitoring tests. The <b>switch <i>number</i></b> keyword is supported only on stacking switches. The range is from 1 to 9. When specifying the tests, use one of these parameters: <ul style="list-style-type: none"> <li>• <i>name</i>—Name of the test that appears in the <b>show diagnostic content</b> command output.</li> <li>• <i>test-id</i>—ID number of the test that appears in the <b>show diagnostic content</b> command output.</li> <li>• <i>test-id-range</i>—ID numbers of the tests that appear in the <b>show diagnostic content</b> command output.</li> <li>• <b>all</b>—All of the diagnostic tests.</li> </ul>

	Command or Action	Purpose
		The range for the failure threshold <i>count</i> is 0 to 99.
<b>Step 6</b>	<p><b>diagnostic monitor switch</b> <i>number</i> <b>test</b> {<i>name</i>   <i>test-id</i>   <i>test-id-range</i>   <b>all</b>}</p> <p><b>Example:</b></p> <pre>Device(config)# diagnostic monitor switch 2 test 1</pre>	<p>Enables the specified health-monitoring tests.</p> <p>The <b>switch</b> <i>number</i> keyword is supported only on stacking switches. The range is from 1 to 9.</p> <p>When specifying the tests, use one of these parameters:</p> <ul style="list-style-type: none"> <li>• <i>name</i>—Name of the test that appears in the <b>show diagnostic content</b> command output.</li> <li>• <i>test-id</i>—ID number of the test that appears in the <b>show diagnostic content</b> command output.</li> <li>• <i>test-id-range</i>—ID numbers of the tests that appear in the <b>show diagnostic content</b> command output.</li> <li>• <b>all</b>—All of the diagnostic tests.</li> </ul>
<b>Step 7</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 8</b>	<p><b>show running-config</b></p> <p><b>Example:</b></p> <pre>Device# show running-config</pre>	Verifies your entries.
<b>Step 9</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

### What to do next

Use the **no diagnostic monitor interval test***test-id* | *test-id-range* } global configuration command to change the interval to the default value or to zero. Use the **no diagnostic monitor syslog** command to disable generation of syslog messages when a health-monitoring test fails. Use the **diagnostic monitor threshold test***test-id* | *test-id-range* } **failure count** command to remove the failure threshold.

# Monitoring and Maintaining Online Diagnostics

## Displaying Online Diagnostic Tests and Test Results

You can display the online diagnostic tests that are configured for the Device or Device stack and check the test results by using the privileged EXEC **show** commands in this table:

*Table 214: Commands for Diagnostic Test Configuration and Results*

Command	Purpose
<b>show diagnostic content switch</b> [ <i>number</i>   <b>all</b> ]	Displays the online diagnostics configured for a switch.
<b>show diagnostic status</b>	Displays the currently running diagnostic tests.
<b>show diagnostic result switch</b> [ <i>number</i>   <b>all</b> ] [ <b>detail</b>   <b>test</b> { <i>name</i>   <i>test-id</i>   <i>test-id-range</i>   <b>all</b> } [ <b>detail</b> ]]	Displays the online diagnostics test results.
<b>show diagnostic switch</b> [ <i>number</i>   <b>all</b> ] [ <b>detail</b> ]	Displays the online diagnostics test results.
<b>show diagnostic schedule switch</b> [ <i>number</i>   <b>all</b> ]	Displays the online diagnostics test schedule.
<b>show diagnostic post</b>	Displays the POST results. (The output is the same as the <b>show post</b> command output.)

## Configuration Examples for Online Diagnostic Tests

### Examples: Start Diagnostic Tests

This example shows how to start a diagnostic test by using the test name:

```
Device# diagnostic start switch 2 test TestInlinePwrCtrl
```

This example shows how to start all of the basic diagnostic tests:

```
Device# diagnostic start switch 1 test all
```

### Example: Configure a Health Monitoring Test

This example shows how to configure a health-monitoring test:

```
Device(config)# diagnostic monitor threshold switch 1 test 1 failure count 50
Device(config)# diagnostic monitor interval switch 1 test TestPortAsicStackPortLoopback
```

## Examples: Schedule Diagnostic Test

This example shows how to schedule diagnostic testing for a specific day and time on a specific switch:

```
Device(config)# diagnostic schedule test DiagThermalTest on June 3 2013 22:25
```

This example shows how to schedule diagnostic testing to occur weekly at a certain time on a specific switch:

```
Device(config)# diagnostic schedule switch 1 test 1,2,4-6 weekly saturday 10:30
```

## Examples: Displaying Online Diagnostics

This example shows how to display on demand diagnostic settings:

```
Device# show diagnostic ondemand settings
```

```
Test iterations = 1
Action on test failure = continue
```

This example shows how to display diagnostic events for errors:

```
Device# show diagnostic events event-type error
```

```
Diagnostic events (storage for 500 events, 0 events recorded)
Number of events matching above criteria = 0
```

```
No diagnostic log entry exists.
```

This example shows how to display the description for a diagnostic test:

```
Device# show diagnostic description switch 1 test all
```

```
DiagGoldPktTest :
```

```
The GOLD packet Loopback test verifies the MAC level loopback
functionality. In this test, a GOLD packet, for which doppler
provides the support in hardware, is sent. The packet loops back
at MAC level and is matched against the stored packet. It is a non
-disruptive test.
```

```
DiagThermalTest :
```

```
This test verifies the temperature reading from the sensor is below the yellow
temperature threshold. It is a non-disruptive test and can be run as a health
monitoring test.
```

```
DiagFanTest :
```

```
This test verifies all fan modules have been inserted and working properly on the
board
```

```
It is a non-disruptive test and can be run as a health monitoring test.
```

```
DiagPhyLoopbackTest :
```

```
The PHY Loopback test verifies the PHY level loopback
functionality. In this test, a packet is sent which loops back
at PHY level and is matched against the stored packet. It is a
disruptive test and cannot be run as a health monitoring test.
```



DiagScratchRegisterTest :

The Scratch Register test monitors the health of application-specific integrated circuits (ASICs) by writing values into registers and reading back the values from these registers. It is a non-disruptive test and can be run as a health monitoring test.

DiagPoETest :

This test checks the PoE controller functionality. This is a disruptive test and should not be performed during normal switch operation.

DiagStackCableTest :

This test verifies the stack ring loopback functionality in the stacking environment. It is a disruptive test and cannot be run as a health monitoring test.

DiagMemoryTest :

This test runs the exhaustive ASIC memory test during normal switch operation. NG3K utilizes mbist for this test. Memory test is very disruptive in nature and requires switch reboot after the test.

Device#

This example shows how to display the boot up level:

```
Device# show diagnostic bootup level
```

```
Current bootup diagnostic level: minimal
```

```
Device#
```

## Additional References for Online Diagnostics

### Related Documents

Related Topic	Document Title
System management commands	<i>System Management Command Reference (Catalyst 3850 Switches)</i>
Platform-independent command reference	<i>Configuration Fundamentals Command Reference, Cisco IOS XE Release 3S (Catalyst 3850 Switches)</i>
Platform-independent configuration information	<i>Configuration Fundamentals Configuration Guide, Cisco IOS XE Release 3S (Catalyst 3850 Switches)</i>

**Standards and RFCs**

Standard/RFC	Title
None	—

**MIBs**

MIB	MIBs Link
All supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for Configuring Online Diagnostics

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.



## CHAPTER 147

# Managing Configuration Files

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- [Prerequisites for Managing Configuration Files, on page 2645](#)
- [Restrictions for Managing Configuration Files, on page 2645](#)
- [Information About Managing Configuration Files, on page 2645](#)
- [How to Manage Configuration File Information, on page 2652](#)
- [Additional References, on page 2679](#)

## Prerequisites for Managing Configuration Files

- You should have at least a basic familiarity with the Cisco IOS environment and the command-line interface.
- You should have at least a minimal configuration running on your system. You can create a basic configuration file using the **setup** command.

## Restrictions for Managing Configuration Files

- Many of the Cisco IOS commands described in this document are available and function only in certain configuration modes on the device.
- Some of the Cisco IOS configuration commands are only available on certain device platforms, and the command syntax may vary on different platforms.

## Information About Managing Configuration Files

### Types of Configuration Files

Configuration files contain the Cisco IOS software commands used to customize the functionality of your Cisco device. Commands are parsed (translated and executed) by the Cisco IOS software when the system is booted (from the startup-config file) or when you enter commands at the CLI in a configuration mode.

Startup configuration files (startup-config) are used during system startup to configure the software. Running configuration files (running-config) contain the current configuration of the software. The two configuration

files can be different. For example, you may want to change the configuration for a short time period rather than permanently. In this case, you would change the running configuration using the **configure terminal** EXEC command but not save the configuration using the **copy running-config startup-config** EXEC command.

To change the running configuration, use the **configure terminal** command, as described in the [Modifying the Configuration File \(CLI\)](#) section. As you use the Cisco IOS configuration modes, commands generally are executed immediately and are saved to the running configuration file either immediately after you enter them or when you exit a configuration mode.

To change the startup configuration file, you can either save the running configuration file to the startup configuration using the **copy running-config startup-config** EXEC command or copy a configuration file from a file server to the startup configuration (see the [Copying a Configuration File from a TFTP Server to the Device \(CLI\)](#) section for more information).

## Configuration Mode and Selecting a Configuration Source

To enter configuration mode on the device, enter the **configure** command at the privileged EXEC prompt. The Cisco IOS software responds with the following prompt asking you to specify the terminal, memory, or a file stored on a network server (network) as the source of configuration commands:

```
Configuring from terminal, memory, or network [terminal]?
```

Configuring from the terminal allows you to enter configuration commands at the command line, as described in the following section. See the [Re-executing the Configuration Commands in the Startup Configuration File \(CLI\)](#) section for more information.

Configuring from the network allows you to load and execute configuration commands over the network. See the [Copying a Configuration File from a TFTP Server to the Device \(CLI\)](#) section for more information.

## Configuration File Changes Using the CLI

The Cisco IOS software accepts one configuration command per line. You can enter as many configuration commands as you want. You can add comments to a configuration file describing the commands you have entered. Precede a comment with an exclamation point (!). Because comments are *not* stored in NVRAM or in the active copy of the configuration file, comments do not appear when you list the active configuration with the **show running-config** or **more system:running-config** EXEC command. Comments are not displayed when you list the startup configuration with the **show startup-config** or **more nvram:startup-config** EXEC mode command. Comments are stripped out of the configuration file when it is loaded onto the device. However, you can list the comments in configuration files stored on a File Transfer Protocol (FTP), Remote Copy Protocol (RCP), or Trivial File Transfer Protocol (TFTP) server. When you configure the software using the CLI, the software executes the commands as you enter them.

## Location of Configuration Files

Configuration files are stored in the following locations:

- The running configuration is stored in RAM.
- On all platforms except the Class A Flash file system platforms, the startup configuration is stored in nonvolatile random-access memory (NVRAM).

- On Class A Flash file system platforms, the startup configuration is stored in the location specified by the CONFIG\_FILE environment variable (see the [Specifying the CONFIG\\_FILE Environment Variable on Class A Flash File Systems \(CLI\)](#) section). The CONFIG\_FILE variable defaults to NVRAM and can be a file in the following file systems:
  - **nvr**am: (NVRAM)
  - **flash**: (internal flash memory)
  - **usbflash0**: (external usbflash file system)

## Copy Configuration Files from a Network Server to the Device

You can copy configuration files from a TFTP, rcp, or FTP server to the running configuration or startup configuration of the device. You may want to perform this function for one of the following reasons:

- To restore a backed-up configuration file.
- To use the configuration file for another device. For example, you may add another device to your network and want it to have a similar configuration to the original device. By copying the file to the new device, you can change the relevant parts rather than recreating the whole file.
- To load the same configuration commands on to all of the devices in your network so that all of the devices have similar configurations.

The **copy {ftp: | rcp: | tftp:system:running-config}** EXEC command loads the configuration files into the device as if you were typing the commands on the command line. The device does not erase the existing running configuration before adding the commands. If a command in the copied configuration file replaces a command in the existing configuration file, the existing command is erased. For example, if the copied configuration file contains a different IP address in a particular command than the existing configuration, the IP address in the copied configuration is used. However, some commands in the existing configuration may not be replaced or negated. In this case, the resulting configuration file is a mixture of the existing configuration file and the copied configuration file, with the copied configuration file having precedence.

To restore a configuration file to an exact copy of a file stored on a server, you need to copy the configuration file directly to the startup configuration (using the **copy ftp: | rcp: | tftp:} nvram:startup-config** command) and reload the device.

To copy configuration files from a server to a device, perform the tasks described in the following sections.

The protocol that you use depends on which type of server you are using. The FTP and rcp transport mechanisms provide faster performance and more reliable delivery of data than TFTP. These improvements are possible because the FTP and rcp transport mechanisms are built on and use the TCP/IP stack, which is connection-oriented.

### Copying a Configuration File from the Device to a TFTP Server

In some implementations of TFTP, you must create a dummy file on the TFTP server and give it read, write, and execute permissions before copying a file over it. Refer to your TFTP documentation for more information.

### Copying a Configuration File from the Device to an RCP Server

You can copy a configuration file from the device to an RCP server.

One of the first attempts to use the network as a resource in the UNIX community resulted in the design and implementation of the remote shell protocol, which included the remote shell (rsh) and remote copy (rcp) functions. Rsh and rcp give users the ability to execute commands remotely and copy files to and from a file system residing on a remote host or server on the network. The Cisco implementation of rsh and rcp interoperates with standard implementations.

The rcp **copy** commands rely on the rsh server (or daemon) on the remote system. To copy files using rcp, you need not create a server for file distribution, as you do with TFTP. You need only have access to a server that supports the remote shell (rsh). (Most UNIX systems support rsh.) Because you are copying a file from one place to another, you must have read permission on the source file and write permission on the destination file. If the destination file does not exist, rcp creates it for you.

Although the Cisco rcp implementation emulates the functions of the UNIX rcp implementation—copying files among systems on the network—the Cisco command syntax differs from the UNIX rcp command syntax. The Cisco rcp support offers a set of **copy** commands that use rcp as the transport mechanism. These rcp **copy** commands are similar in style to the Cisco TFTP **copy** commands, but they offer an alternative that provides faster performance and reliable delivery of data. These improvements are possible because the rcp transport mechanism is built on and uses the TCP/IP stack, which is connection-oriented. You can use rcp commands to copy system images and configuration files from the device to a network server and vice versa.

You also can enable rcp support to allow users on remote systems to copy files to and from the device.

To configure the Cisco IOS software to allow remote users to copy files to and from the device, use the **ip rcmd rcp-enable** global configuration command.

## Restrictions

The RCP protocol requires a client to send a remote username on each RCP request to a server. When you copy a configuration file from the device to a server using RCP, the Cisco IOS software sends the first valid username it encounters in the following sequence:

1. The username specified in the **copy EXEC** command, if a username is specified.
2. The username set by the **ip rcmd remote-username** global configuration command, if the command is configured.
3. The remote username associated with the current tty (terminal) process. For example, if the user is connected to the device through Telnet and was authenticated through the **username** command, the device software sends the Telnet username as the remote username.
4. The device host name.

For the RCP copy request to execute successfully, an account must be defined on the network server for the remote username. If the server has a directory structure, the configuration file or image is written to or copied from the directory associated with the remote username on the server. For example, if the system image resides in the home directory of a user on the server, you can specify that user name as the remote username.

Use the **ip rcmd remote-username** command to specify a username for all copies. (Rcmd is a UNIX routine used at the super-user level to execute commands on a remote machine using an authentication scheme based on reserved port numbers. Rcmd stands for “remote command”). Include the username in the **copy** command if you want to specify a username for that copy operation only.

If you are writing to the server, the RCP server must be properly configured to accept the RCP write request from the user on the device. For UNIX systems, you must add an entry to the .rhosts file for the remote user on the RCP server. For example, suppose the device contains the following configuration lines:

```
hostname Device1
ip rcmd remote-username User0
```

If the device IP address translates to device1.example.com, then the .rhosts file for User0 on the RCP server should contain the following line:

```
Device1.example.com Device1
```

### Requirements for the RCP Username

The RCP protocol requires a client to send a remote username on each RCP request to a server. When you copy a configuration file from the device to a server using RCP, the Cisco IOS software sends the first valid username it encounters in the following sequence:

1. The username specified in the **copy EXEC** command, if a username is specified.
2. The username set by the **ip rcmd remote-username** global configuration command, if the command is configured.
3. The remote username associated with the current tty (terminal) process. For example, if the user is connected to the device through Telnet and is authenticated through the **username** command, the device software sends the Telnet username as the remote username.
4. The device host name.

For the RCP copy request to execute, an account must be defined on the network server for the remote username. If the server has a directory structure, the configuration file or image is written to or copied from the directory associated with the remote username on the server. For example, if the system image resides in the home directory of a user on the server, specify that user name as the remote username.

Refer to the documentation for your RCP server for more information.

## Copying a Configuration File from the Device to an FTP Server

You can copy a configuration file from the device to an FTP server.

### Understanding the FTP Username and Password



**Note** The password must not contain the special character '@'. If the character '@' is used, the copy fails to parse the IP address of the server.

The FTP protocol requires a client to send a remote username and password on each FTP request to a server. When you copy a configuration file from the device to a server using FTP, the Cisco IOS software sends the first valid username it encounters in the following sequence:

1. The username specified in the **copy EXEC** command, if a username is specified.
2. The username set by the **ip ftp username** global configuration command, if the command is configured.
3. Anonymous.

The device sends the first valid password it encounters in the following sequence:

1. The password specified in the **copy** command, if a password is specified.
2. The password set by the **ip ftp password** command, if the command is configured.
3. The device forms a password *username@devicename.domain*. The variable *username* is the username associated with the current session, *devicename* is the configured host name, and *domain* is the domain of the device.

The username and password must be associated with an account on the FTP server. If you are writing to the server, the FTP server must be properly configured to accept the FTP write request from the user on the device.

If the server has a directory structure, the configuration file or image is written to or copied from the directory associated with the username on the server. For example, if the system image resides in the home directory of a user on the server, specify that user name as the remote username.

Refer to the documentation for your FTP server for more information.

Use the **ip ftp username** and **ip ftp password** global configuration commands to specify a username and password for all copies. Include the username in the **copy EXEC** command if you want to specify a username for that copy operation only.

## Copying files through a VRF

You can copy files through a VRF interface specified in the **copy** command. Specifying the VRF in the **copy** command is easier and more efficient as you can directly change the source interface without using a change request for the configuration.

### Example

The following example shows how to copy files through a VRF, using the **copy** command:

```
Device# copy scp: flash-1: vrf test-vrf
Address or name of remote host [10.1.2.3]?
Source username [ScpUser]?
Source filename [/auto/tftp-server/ScpUser/vrf_test.txt]?
Destination filename [vrf_test.txt]?
Getting the vrf name as test-vrf
Password:
Sending file modes: C0644 10 vrf_test.txt
!
223 bytes copied in 22.740 secs (10 bytes/sec)
```

## Copy Configuration Files from a Switch to Another Switch

You can copy the configurations from one switch to another. This is a 2-step process - Copy the configurations from the switch to the TFTP server, and then from TFTP to another switch.

To copy your current configurations from the switch, run the command **copy startup-config tftp:** and follow the instructions. The configurations are copied onto the TFTP server.

Then, login to another switch and run the command **copy tftp: startup-config** and follow the instructions. The configurations are now copied onto the other switch.

After the configurations are copied, to save your configurations, use **write memory** command and then either reload the switch or run the **copy startup-config running-config** command



For more information, see *Cisco IOS Configuration Fundamentals Command Reference, Cisco IOS XE Release 16.1 (Catalyst 3850 Switches)*.

## Configuration Files Larger than NVRAM

To maintain a configuration file that exceeds the size of NVRAM, you should be aware of the information in the following sections.

### Compressing the Configuration File

The **service compress-config** global configuration command specifies that the configuration file be stored compressed in NVRAM. Once the configuration file has been compressed, the device functions normally. When the system is booted, it recognizes that the configuration file is compressed, expands it, and proceeds normally. The **more nvram:startup-config EXEC** command expands the configuration before displaying it.

Before you compress configuration files, refer to the appropriate hardware installation and maintenance publication. Verify that your system's ROMs support file compression. If not, you can install new ROMs that support file compression.

The size of the configuration must not exceed three times the NVRAM size. For a 128-KB size NVRAM, the largest expanded configuration file size is 384 KB.

The **service compress-config** global configuration command works only if you have Cisco IOS software Release 10.0 or later release boot ROMs. Installing new ROMs is a one-time operation and is necessary only if you do not already have Cisco IOS Release 10.0 in ROM. If the boot ROMs do not recognize a compressed configuration, the following message is displayed:

```
Boot ROMs do not support NVRAM compression Config NOT written to NVRAM
```

### Storing the Configuration in Flash Memory on Class A Flash File Systems

On class A Flash file system devices, you can store the startup configuration in flash memory by setting the **CONFIG\_FILE** environment variable to a file in internal flash memory or flash memory in a PCMCIA slot.

See the [Specifying the CONFIG\\_FILE Environment Variable on Class A Flash File Systems \(CLI\)](#) section for more information.

Care must be taken when editing or changing a large configuration. Flash memory space is used every time a **copy system:running-config nvram:startup-config EXEC** command is issued. Because file management for flash memory (such as optimizing free space) is not done automatically, you must pay close attention to available flash memory. Use the **squeeze** command to reclaim used space. We recommend that you use a large-capacity Flash card of at least 20 MB.

### Loading the Configuration Commands from the Network

You can also store large configurations on FTP, RCP, or TFTP servers and download them at system startup. To use a network server to store large configurations, see the [Copying a Configuration File from the Device to a TFTP Server \(CLI\)](#) and [Configuring the Device to Download Configuration Files](#) sections for more information on these commands.

## Configuring the Device to Download Configuration Files

You can configure the device to load one or two configuration files at system startup. The configuration files are loaded into memory and read in as if you were typing the commands at the command line. Thus, the configuration for the device is a mixture of the original startup configuration and the one or two downloaded configuration files.

### Network Versus Host Configuration Files

For historical reasons, the first file the device downloads is called the network configuration file. The second file the device downloads is called the host configuration file. Two configuration files can be used when all of the devices on a network use many of the same commands. The network configuration file contains the standard commands used to configure all of the devices. The host configuration files contain the commands specific to one particular host. If you are loading two configuration files, the host configuration file should be the configuration file you want to have precedence over the other file. Both the network and host configuration files must reside on a network server reachable via TFTP, RCP, or FTP, and must be readable.

## How to Manage Configuration File Information

### Displaying Configuration File Information (CLI)

To display information about configuration files, complete the tasks in this section:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>show boot</b> <b>Example:</b> Device# show boot	Lists the contents of the BOOT environment variable (if set), the name of the configuration file pointed to by the CONFIG_FILE environment variable, and the contents of the BOOTLDR environment variable.
<b>Step 3</b>	<b>more file-url</b> <b>Example:</b> Device# more 10.1.1.1	Displays the contents of a specified file.
<b>Step 4</b>	<b>show running-config</b> <b>Example:</b> Device# show running-config	Displays the contents of the running configuration file. (Command alias for the <b>more system:running-config</b> command.)

	Command or Action	Purpose
<b>Step 5</b>	<b>show startup-config</b> <b>Example:</b> <pre>Device# show startup-config</pre>	<p>Displays the contents of the startup configuration file. (Command alias for the <b>more nvram:startup-config</b> command.)</p> <p>On all platforms except the Class A Flash file system platforms, the default startup-config file usually is stored in NVRAM.</p> <p>On the Class A Flash file system platforms, the CONFIG_FILE environment variable points to the default startup-config file.</p> <p>The CONFIG_FILE variable defaults to NVRAM.</p>

## Modifying the Configuration File (CLI)

The Cisco IOS software accepts one configuration command per line. You can enter as many configuration commands as you want. You can add comments to a configuration file describing the commands you have entered. Precede a comment with an exclamation point (!). Because comments are *not* stored in NVRAM or in the active copy of the configuration file, comments do not appear when you list the active configuration with the **show running-config** or **more system:running-config EXEC** commands. Comments do not display when you list the startup configuration with the **show startup-config** or **more nvram:startup-config EXEC** mode commands. Comments are stripped out of the configuration file when it is loaded onto the device. However, you can list the comments in configuration files stored on a File Transfer Protocol (FTP), Remote Copy Protocol (RCP), or Trivial File Transfer Protocol (TFTP) server. When you configure the software using the CLI, the software executes the commands as you enter them. To configure the software using the CLI, use the following commands in privileged EXEC mode:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	<p>Enters global configuration mode.</p>
<b>Step 3</b>	<b>configuration command</b> <b>Example:</b> <pre>Device(config)# configuration command</pre>	<p>Enter the necessary configuration commands. The Cisco IOS documentation set describes configuration commands organized by technology.</p>

	Command or Action	Purpose
<b>Step 4</b>	Do one of the following: <ul style="list-style-type: none"> <li>• <b>end</b></li> <li>• <b>^Z</b></li> </ul> <b>Example:</b> <pre>Device(config)# end</pre>	Ends the configuration session and exits to EXEC mode.  <b>Note</b> When you press the Ctrl and Z keys simultaneously, ^Z is displayed to the screen.
<b>Step 5</b>	<b>copy system:running-config nvram:startup-config</b>  <b>Example:</b> <pre>Device# copy system:running-config nvram:startup-config</pre>	Saves the running configuration file as the startup configuration file.  You may also use the <b>copy running-config startup-config</b> command alias, but you should be aware that this command is less precise. On most platforms, this command saves the configuration to NVRAM. On the Class A Flash file system platforms, this step saves the configuration to the location specified by the CONFIG_FILE environment variable (the default CONFIG_FILE variable specifies that the file should be saved to NVRAM).

## Examples

In the following example, the device prompt name of the device is configured. The comment line, indicated by the exclamation mark (!), does not execute any command. The **hostname** command is used to change the device name from device to new\_name. By pressing Ctrl-Z (^Z) or entering the **end** command, the user quits configuration mode. The **copy system:running-config nvram:startup-config** command saves the current configuration to the startup configuration.

```
Device# configure terminal
Device(config)# !The following command provides the switch host name.
Device(config)# hostname new_name
new_name(config)# end
new_name# copy system:running-config nvram:startup-config
```

When the startup configuration is NVRAM, it stores the current configuration information in text format as configuration commands, recording only non-default settings. The memory is checksummed to guard against corrupted data.



### Note

Some specific commands might not get saved to NVRAM. You need to enter these commands again if you reboot the machine. These commands are noted in the documentation. We recommend that you keep a list of these settings so that you can quickly reconfigure your device after rebooting.

## Copying a Configuration File from the Device to a TFTP Server (CLI)

To copy configuration information on a TFTP network server, complete the tasks in this section:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>copy system:running-config tftp: [///location ]/directory ]/filename ]</b> <b>Example:</b> Device# copy system:running-config tftp://server1/topdir/file10	Copies the running configuration file to a TFTP server.
<b>Step 3</b>	<b>copy nvram:startup-config tftp: [///location ]/directory ]/filename ]</b> <b>Example:</b> Device# copy nvram:startup-config tftp://server1/1stdir/file10	Copies the startup configuration file to a TFTP server.

### Examples

The following example copies a configuration file from a device to a TFTP server:

```
Device# copy system:running-config tftp://172.16.2.155/tokyo-config
Write file tokyo-config on host 172.16.2.155? [confirm] Y
Writing tokyo-config!!! [OK]
```

## What to Do Next

After you have issued the **copy** command, you may be prompted for additional information or for confirmation of the action. The prompt displayed depends on how much information you provide in the **copy** command and the current setting of the **file prompt** global configuration command.

## Copying a Configuration File from the Device to an RCP Server (CLI)

To copy a startup configuration file or a running configuration file from the device to an RCP server, use the following commands beginning in privileged EXEC mode:

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>ip rcmd remote-username <i>username</i></b> <b>Example:</b> <pre>Device(config)# ip rcmd remote-username NetAdmin1</pre>	(Optional) Changes the default remote username.
<b>Step 4</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	(Optional) Exits global configuration mode.
<b>Step 5</b>	Do one of the following: <ul style="list-style-type: none"> <li>• <b>copy system:running-config rcp:</b>  <code>[[[/<i>username@</i>]<i>location</i> ]/<i>directory</i> ]/<i>filename</i> ]</code></li> <li>• <b>copy nvram:startup-config rcp:</b>  <code>[[[/<i>username@</i>]<i>location</i> ]/<i>directory</i> ]/<i>filename</i> ]</code></li> </ul> <b>Example:</b> <pre>Device# copy system:running-config rcp: //NetAdmin1@example.com/dir-files/file1</pre>	<ul style="list-style-type: none"> <li>• Specifies that the device running configuration file is to be stored on an RCP server</li> <li>or</li> <li>• Specifies that the device startup configuration file is to be stored on an RCP server</li> </ul>

**Examples****Storing a Running Configuration File on an RCP Server**

The following example copies the running configuration file named `runfile2-config` to the `netadmin1` directory on the remote host with an IP address of `172.16.101.101`:

```
Device# copy system:running-config rcp://netadmin1@172.16.101.101/runfile2-config
Write file runfile2-config on host 172.16.101.101?[confirm]
Building configuration...[OK]
Connected to 172.16.101.101
Device#
```

## Storing a Startup Configuration File on an RCP Server

The following example shows how to store a startup configuration file on a server by using RCP to copy the file:

```
Device# configure terminal
Device(config)# ip rcmd remote-username netadmin2
Device(config)# end
Device# copy nvram:startup-config rcp:
Remote host[]? 172.16.101.101
Name of configuration file to write [start-config]?
Write file start-config on host 172.16.101.101?[confirm]
![OK]
```

## What to Do Next

After you have issued the **copy EXEC** command, you may be prompted for additional information or for confirmation of the action. The prompt displayed depends on how much information you provide in the **copy** command and the current setting of the **file prompt** global configuration command.

## Copying a Configuration File from the Device to the FTP Server (CLI)

To copy a startup configuration file or a running configuration file from the device to an FTP server, complete the following tasks:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	Enters global configuration mode on the device.
<b>Step 3</b>	<b>ip ftp username <i>username</i></b> <b>Example:</b>  Device(config)# ip ftp username NetAdmin1	(Optional) Specifies the default remote username.
<b>Step 4</b>	<b>ip ftp password <i>password</i></b> <b>Example:</b>	(Optional) Specifies the default password.

	Command or Action	Purpose
	Device(config)# ip ftp password adminpassword	
<b>Step 5</b>	<b>end</b>  <b>Example:</b>  Device(config)# end	(Optional) Exits global configuration mode. This step is required only if you override the default remote username or password (see Steps 2 and 3).
<b>Step 6</b>	Do one of the following:  <ul style="list-style-type: none"> <li>• <b>copy system:running-config ftp:</b> [[[/[username [:password ]@]location]/directory ]/filename ] or</li> <li>• <b>copy nvram:startup-config ftp:</b> [[[/[username [:password ]@]location]/directory ]/filename ]</li> </ul> <b>Example:</b>  Device# copy system:running-config ftp:	Copies the running configuration or startup configuration file to the specified location on the FTP server.

## Examples

### Storing a Running Configuration File on an FTP Server

The following example copies the running configuration file named runfile-config to the netadmin1 directory on the remote host with an IP address of 172.16.101.101:

```
Device# copy system:running-config ftp://netadmin1:mypass@172.16.101.101/runfile-config
Write file runfile-config on host 172.16.101.101?[confirm]
Building configuration...[OK]
Connected to 172.16.101.101
Device#
```

### Storing a Startup Configuration File on an FTP Server

The following example shows how to store a startup configuration file on a server by using FTP to copy the file:

```
Device# configure terminal

Device(config)# ip ftp username netadmin2

Device(config)# ip ftp password mypass

Device(config)# end

Device# copy nvram:startup-config ftp:

Remote host[ ]? 172.16.101.101

Name of configuration file to write [start-config]?
Write file start-config on host 172.16.101.101?[confirm]
![OK]
```



## What to Do Next

After you have issued the **copy EXEC** command, you may be prompted for additional information or for confirmation of the action. The prompt displayed depends on how much information you provide in the **copy** command and the current setting of the **file prompt** global configuration command.

## Copying a Configuration File from a TFTP Server to the Device (CLI)

To copy a configuration file from a TFTP server to the device, complete the tasks in this section:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>copy tftp: [[[//location]/directory]/filename]</b> <b>system:running-config</b> <b>Example:</b> <pre>Device# copy tftp://server1/dir10/datasource system:running-config</pre>	Copies a configuration file from a TFTP server to the running configuration.
<b>Step 3</b>	<b>copy tftp: [[[//location]/directory]/filename]</b> <b>nvrnram:startup-config</b> <b>Example:</b> <pre>Device# copy tftp://server1/dir10/datasource nvrnram:startup-config</pre>	Copies a configuration file from a TFTP server to the startup configuration.
<b>Step 4</b>	<b>copy tftp: [[[//location]/directory]/filename]</b> <b>flash-[n]/directory/startup-config</b> <b>Example:</b> <pre>Device# copy tftp://server1/dir10/datasource flash:startup-config</pre>	Copies a configuration file from a TFTP server to the startup configuration.

### Examples

In the following example, the software is configured from the file named **tokyo-config** at IP address 172.16.2.155:

```
Device# copy tftp://172.16.2.155/tokyo-config system:running-config
```

```
Configure using tokyo-config from 172.16.2.155? [confirm] Y
```

```
Booting tokyo-config from 172.16.2.155:!!! [OK - 874/16000 bytes]
```

## What to Do Next

After you have issued the **copy EXEC** command, you may be prompted for additional information or for confirmation of the action. The prompt displayed depends on how much information you provide in the **copy** command and the current setting of the **file prompt** global configuration command.

## Copying a Configuration File from the rcp Server to the Device (CLI)

To copy a configuration file from an rcp server to the running configuration or startup configuration, complete the following tasks:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	(Optional) Enters configuration mode from the terminal. This step is required only if you override the default remote username (see Step 3).
<b>Step 3</b>	<b>ip rcmd remote-username <i>username</i></b> <b>Example:</b> Device(config)# ip rcmd remote-username NetAdmin1	(Optional) Specifies the remote username.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# end	(Optional) Exits global configuration mode. This step is required only if you override the default remote username (see Step 2).
<b>Step 5</b>	Do one of the following: <ul style="list-style-type: none"> <li>• copy  <code>ip://username@hostname/remote-systemrunningconf</code></li> <li>• copy  <code>ip://username@hostname/remote-manastartupconf</code></li> </ul> <b>Example:</b> Device# copy	Copies the configuration file from an rcp server to the running configuration or startup configuration.

	Command or Action	Purpose
	<code>rcp://[user1@example.com/dir10/fileone] nvram:startup-config</code>	

## Examples

### Copy RCP Running-Config

The following example copies a configuration file named `host1-config` from the `netadmin1` directory on the remote server with an IP address of `172.16.101.101`, and loads and runs the commands on the device:

```
Device# copy rcp://netadmin1@172.16.101.101/host1-config system:running-config
Configure using host1-config from 172.16.101.101? [confirm]
Connected to 172.16.101.101
Loading 1112 byte file host1-config:[OK]
Device#
%SYS-5-CONFIG: Configured from host1-config by rcp from 172.16.101.101
```

### Copy RCP Startup-Config

The following example specifies a remote username of `netadmin1`. Then it copies the configuration file named `host2-config` from the `netadmin1` directory on the remote server with an IP address of `172.16.101.101` to the startup configuration.

```
Device# configure terminal
Device(config)# ip rcmd remote-username netadmin1
Device(config)# end
Device# copy rcp: nvram:startup-config
Address of remote host [255.255.255.255]? 172.16.101.101
Name of configuration file[rtr2-config]? host2-config
Configure using host2-config from 172.16.101.101?[confirm]
Connected to 172.16.101.101
Loading 1112 byte file host2-config:[OK]
[OK]
Device#
%SYS-5-CONFIG_NV:Non-volatile store configured from host2-config by rcp from 172.16.101.101
```

## What to Do Next

After you have issued the `copy EXEC` command, you may be prompted for additional information or for confirmation of the action. The prompt displayed depends on how much information you provide in the `copy` command and the current setting of the `file prompt` global configuration command.

## Copying a Configuration File from an FTP Server to the Device (CLI)

To copy a configuration file from an FTP server to the running configuration or startup configuration, complete the tasks in this section:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<code>enable</code>	Enables privileged EXEC mode.

	Command or Action	Purpose
	<b>Example:</b>  Device> enable	<ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# configure terminal	(Optional) Allows you to enter global configuration mode. This step is required only if you want to override the default remote username or password (see Steps 3 and 4).
<b>Step 3</b>	<b>ip ftp username <i>username</i></b>  <b>Example:</b>  Device(config)# ip ftp username NetAdmin1	(Optional) Specifies the default remote username.
<b>Step 4</b>	<b>ip ftp password <i>password</i></b>  <b>Example:</b>  Device(config)# ip ftp password adminpassword	(Optional) Specifies the default password.
<b>Step 5</b>	<b>end</b>  <b>Example:</b>  Device(config)# end	(Optional) Exits global configuration mode. This step is required only if you override the default remote username or password (see Steps 3 and 4).
<b>Step 6</b>	Do one of the following: <ul style="list-style-type: none"> <li>• <b>copy ftp:</b>                [[[/[<i>username</i>[:<i>password</i>]@]<i>location</i>]                /<i>directory</i>                ]/<i>filename</i>]<b>system:running-config</b></li> <li>• <b>copy ftp:</b> [[  <del>[[[/[<i>username</i>[:<i>password</i>]@]<i>location</i>]                /<i>directory</i>                ]/<i>filename</i>]<b>system:running-config</b></del>  <del>[[[/[<i>username</i>[:<i>password</i>]@]<i>location</i>]                /<i>directory</i>                ]/<i>filename</i>]<b>system:startup-config</b></del></li> </ul> <b>Example:</b>  Device# copy ftp:nvram:startup-config	Using FTP copies the configuration file from a network server to running memory or the startup configuration.

## Examples

### Copy FTP Running-Config

The following example copies a host configuration file named host1-config from the netadmin1 directory on the remote server with an IP address of 172.16.101.101, and loads and runs the commands on the device:

```
Device# copy ftp://netadmin1:mypass@172.16.101.101/host1-config system:running-config
Configure using host1-config from 172.16.101.101? [confirm]
Connected to 172.16.101.101
Loading 1112 byte file host1-config:![OK]
```

```
Device#
%SYS-5-CONFIG: Configured from host1-config by ftp from 172.16.101.101
```

## Copy FTP Startup-Config

The following example specifies a remote username of netadmin1. Then it copies the configuration file named host2-config from the netadmin1 directory on the remote server with an IP address of 172.16.101.101 to the startup configuration:

```
Device# configure terminal
Device(config)# ip ftp username netadmin1
Device(config)# ip ftp password mypass
Device(config)# end
Device# copy ftp: nvram:startup-config
Address of remote host [255.255.255.255]? 172.16.101.101
Name of configuration file[host1-config]? host2-config
Configure using host2-config from 172.16.101.101?[confirm]
Connected to 172.16.101.101
Loading 1112 byte file host2-config:[OK]
[OK]
Device#
%SYS-5-CONFIG_NV:Non-volatile store configured from host2-config by ftp from 172.16.101.101
```

## What to Do Next

After you have issued the **copy EXEC** command, you may be prompted for additional information or for confirmation of the action. The prompt displayed depends on how much information you provide in the **copy** command and the current setting of the **file prompt** global configuration command.

## Maintaining Configuration Files Larger than NVRAM

To maintain a configuration file that exceeds the size of NVRAM, perform the tasks described in the following sections:

### Compressing the Configuration File (CLI)

To compress configuration files, complete the tasks in this section:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>service compress-config</b> <b>Example:</b> Device(config)# service compress-config	Specifies that the configuration file be compressed.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# end	Exits global configuration mode.
<b>Step 5</b>	Do one of the following: <ul style="list-style-type: none"> <li>• Use FTP, RCP, or TFTP to copy the new configuration.</li> <li>• <b>configure terminal</b></li> </ul> <b>Example:</b> Device# configure terminal	Enters the new configuration: <ul style="list-style-type: none"> <li>• If you try to load a configuration that is more than three times larger than the NVRAM size, the following error message is displayed:</li> </ul> “[buffer overflow - <i>file-size</i> / <i>buffer-size</i> bytes].”
<b>Step 6</b>	<b>copy system:running-config nvrRam:startup-config</b> <b>Example:</b> Device(config)# copy system:running-config nvrRam:startup-config	When you have finished changing the running-configuration, save the new configuration.

## Examples

The following example compresses a 129-KB configuration file to 11 KB:

```

Device# configure terminal
Device(config)# service compress-config
Device(config)# end

Device# copy tftp://172.16.2.15/tokyo-config system:running-config
Configure using tokyo-config from 172.16.2.155? [confirm] y
Booting tokyo-config from 172.16.2.155:!!! [OK - 874/16000 bytes]
Device# copy system:running-config nvrRam:startup-config

Building configuration...
Compressing configuration from 129648 bytes to 11077 bytes
[OK]

```

## Storing the Configuration in Flash Memory on Class A Flash File Systems (CLI)

To store the startup configuration in flash memory, complete the tasks in this section:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>copy nvram:startup-config</b> <i>flash-filesystem:filename</i> <b>Example:</b> <pre>Device# copy nvram:startup-config usbflash0:switch-config</pre>	Copies the current startup configuration to the new location to create the configuration file.
<b>Step 3</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 4</b>	<b>boot config flash-filesystem: filename</b> <b>Example:</b> <pre>Device(config)# boot config usbflash0:switch-config</pre>	Specifies that the startup configuration file be stored in flash memory by setting the CONFIG_FILE variable.
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Exits global configuration mode.
<b>Step 6</b>	Do one of the following: <ul style="list-style-type: none"> <li>• Use FTP, RCP, or TFTP to copy the new configuration. If you try to load a configuration that is more than three times larger than the NVRAM size, the following error message is displayed: “[buffer overflow - file-size /buffer-size bytes].”</li> <li>• <b>configure terminal</b></li> </ul> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters the new configuration.

	Command or Action	Purpose
<b>Step 7</b>	<b>copy system:running-config nvram:startup-config</b>  <b>Example:</b>  <pre>Device(config)# copy system:running-config nvram:startup-config</pre>	When you have finished changing the running-configuration, save the new configuration.

### Examples

The following example stores the configuration file in usbflash0:

```
Device# copy nvram:startup-config usbflash0:switch-config
Device# configure terminal
Device(config)# boot config usbflash0:switch-config
Device(config)# end
Device# copy system:running-config nvram:startup-config
```

## Loading the Configuration Commands from the Network (CLI)

To use a network server to store large configurations, complete the tasks in this section:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>copy system:running-config {ftp:   rcp:   tftp:}</b>  <b>Example:</b>  <pre>Device# copy system:running-config ftp:</pre>	Saves the running configuration to an FTP, RCP, or TFTP server.
<b>Step 3</b>	<b>configure terminal</b>  <b>Example:</b>  <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 4</b>	<b>boot network {ftp:[[[/[username [:password ]@]location ]/directory ]/filename ]   rcp:[[[/[username@]location ]/directory</b>	Specifies that the startup configuration file be loaded from the network server at startup.



	Command or Action	Purpose
	<pre>]/filename ]   tftp:[[[//location ]/directory ]/filename ]}  <b>Example:</b>  Device(config)# boot network ftp://user1:guessme@example.com/dir10/file1</pre>	
<b>Step 5</b>	<pre><b>service config</b>  <b>Example:</b>  Device(config)# service config</pre>	Enables the switch to download configuration files at system startup.
<b>Step 6</b>	<pre><b>end</b>  <b>Example:</b>  Device(config)# end</pre>	Exits global configuration mode.
<b>Step 7</b>	<pre><b>copy system:running-config nvram:startup-config</b>  <b>Example:</b>  Device# copy system:running-config nvram:startup-config</pre>	Saves the configuration.

## Copying Configuration Files from Flash Memory to the Startup or Running Configuration (CLI)

To copy a configuration file from flash memory directly to your startup configuration in NVRAM or your running configuration, enter one of the commands in Step 2:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<pre><b>enable</b>  <b>Example:</b>  Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<p>Do one of the following:</p> <ul style="list-style-type: none"> <li>• <b>copy filesystem:</b> [partition-number:][filename ] <b>nvram:startup-config</b></li> <li>• <b>copy filesystem:</b> [partition-number:][filename ] <b>system:running-config</b></li> </ul>	<ul style="list-style-type: none"> <li>• Loads a configuration file directly into NVRAM or</li> <li>• Copies a configuration file to your running configuration</li> </ul>

	Command or Action	Purpose
	<b>Example:</b>  Device# copy usbflash0:4:ios-upgrade-1 nvram:startup-config	

### Examples

The following example copies the file named ios-upgrade-1 from partition 4 of the flash memory PC Card in usbflash0 to the device startup configurations:

```
Device# copy usbflash0:4:ios-upgrade-1 nvram:startup-config
```

```
Copy 'ios-upgrade-1' from flash device as 'startup-config' ? [yes/no] yes
```

```
[OK]
```

## Copying Configuration Files Between Flash Memory File Systems (CLI)

On platforms with multiple flash memory file systems, you can copy files from one flash memory file system, such as internal flash memory to another flash memory file system. Copying files to different flash memory file systems lets you create backup copies of working configurations and duplicate configurations for other devices. To copy a configuration file between flash memory file systems, use the following commands in EXEC mode:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>show source-filesystem:</b>  <b>Example:</b>  Device# show flash:	Displays the layout and contents of flash memory to verify the filename.
<b>Step 3</b>	<b>copy source-filesystem:</b> <i>[partition-number:][filename ]</i> <i>dest-filesystem:[partition-number:][filename ]</i>  <b>Example:</b>  Device# copy flash: usbflash0:	Copies a configuration file between flash memory devices. <ul style="list-style-type: none"> <li>• The source device and the destination device cannot be the same. For example, the <b>copy usbflash0: usbflash0:</b> command is invalid.</li> </ul>



	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# configure terminal	(Optional) Enters global configuration mode. This step is required only if you override the default remote username or password (see Steps 3 and 4).
<b>Step 3</b>	<b>ip ftp username <i>username</i></b> <b>Example:</b>  Device(config)# ip ftp username Admin01	(Optional) Specifies the remote username.
<b>Step 4</b>	<b>ip ftp password <i>password</i></b> <b>Example:</b>  Device(config)# ip ftp password adminpassword	(Optional) Specifies the remote password.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config)# end	(Optional) Exits configuration mode. This step is required only if you override the default remote username (see Steps 3 and 4).
<b>Step 6</b>	<b>copy ftp: [[//location]/directory ]/bundle_name</b> <b>flash:</b> <b>Example:</b>  Device>copy ftp://cat3k-ca-universal9.SSA.03.12.02.EZP.150-12.02.EZP.150-12.02.EZP.bin flash:	Copies the configuration file from a network server to the flash memory device using FTP.

## What to Do Next

After you have issued the **copy** EXEC command, you may be prompted for additional information or for confirmation of the action. The prompt displayed depends on how much information you provide in the **copy** command and the current setting of the **file prompt** global configuration command.

## Copying a Configuration File from an RCP Server to Flash Memory Devices (CLI)

To copy a configuration file from an RCP server to a flash memory device, complete the tasks in this section:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
	Device> enable	
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	(Optional) Enters global configuration mode. This step is required only if you override the default remote username or password (see Step 3).
<b>Step 3</b>	<b>ip rcmd remote-username <i>username</i></b> <b>Example:</b> Device(config)# ip rcmd remote-username Admin01	(Optional) Specifies the remote username.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# end	(Optional) Exits configuration mode. This step is required only if you override the default remote username or password (see Step 3).
<b>Step 5</b>	<b>copy rcp: [[[//]<i>username@</i>]<i>location</i> ]/<i>directory</i> ]/<i>bundle_name</i> flash:</b> <b>Example:</b> Device# copy rcp://netadmin@172.16.101.101/bundle1 flash:	Copies the configuration file from a network server to the flash memory device using RCP. Respond to any device prompts for additional information or confirmation. Prompting depends on how much information you provide in the <b>copy</b> command and the current setting of the <b>file prompt</b> command.

## Copying a Configuration File from a TFTP Server to Flash Memory Devices (CLI)

To copy a configuration file from a TFTP server to a flash memory device, complete the tasks in this section:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>copy tftp: [[[//]<i>location</i> ]/<i>directory</i> ]/<i>bundle_name</i> flash:</b> <b>Example:</b> Device# copy	Copies the file from a TFTP server to the flash memory device. Reply to any device prompts for additional information or confirmation. Prompting depends on how much information you provide in the <b>copy</b> command and the current setting of the <b>file prompt</b> command.

	Command or Action	Purpose
	<code>tftp://cat3k-aaa-universall9.SSA.03.12.02.EZP.150-12.02.EZP.150-12.02.EZP.bin</code> flash:	

### Examples

The following example shows the copying of the configuration file named switch-config from a TFTP server to the flash memory card inserted in usbflash0. The copied file is renamed new-config.

```
Device#
copy tftp:switch-config usbflash0:new-config
```

## Re-executing the Configuration Commands in the Startup Configuration File (CLI)

To re-execute the commands located in the startup configuration file, complete the task in this section:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure memory</b>  <b>Example:</b>  Device# configure memory	Re-executes the configuration commands located in the startup configuration file.

## Clearing the Startup Configuration (CLI)

You can clear the configuration information from the startup configuration. If you reboot the device with no startup configuration, the device enters the Setup command facility so that you can configure the device from scratch. To clear the contents of your startup configuration, complete the task in this section:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.

	Command or Action	Purpose
<b>Step 2</b>	<b>erase nvram</b> <b>Example:</b> <pre>Device# erase nvram</pre>	<p>Clears the contents of your startup configuration.</p> <p><b>Note</b> For all platforms except the Class A Flash file system platforms, this command erases NVRAM. The startup configuration file cannot be restored once it has been deleted. On Class A Flash file system platforms, when you use the <b>erase startup-config EXEC</b> command, the device erases or deletes the configuration pointed to by the CONFIG_FILE environment variable. If this variable points to NVRAM, the device erases NVRAM. If the CONFIG_FILE environment variable specifies a flash memory device and configuration filename, the device deletes the configuration file. That is, the device marks the file as “deleted,” rather than erasing it. This feature allows you to recover a deleted file.</p>

## Deleting a Specified Configuration File (CLI)

To delete a specified configuration on a specific flash device, complete the task in this section:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>delete <i>flash-filesystem:filename</i></b> <b>Example:</b>	<p>Deletes the specified configuration file on the specified flash device.</p>

	Command or Action	Purpose
	Device# delete usbflash0:myconfig	<p><b>Note</b> On Class A and B Flash file systems, when you delete a specific file in flash memory, the system marks the file as deleted, allowing you to later recover a deleted file using the <b>undelete</b> EXEC command. Erased files cannot be recovered. To permanently erase the configuration file, use the <b>squeeze</b> EXEC command. On Class C Flash file systems, you cannot recover a file that has been deleted. If you attempt to erase or delete the configuration file specified by the CONFIG_FILE environment variable, the system prompts you to confirm the deletion.</p>

## Specifying the CONFIG\_FILE Environment Variable on Class A Flash File Systems (CLI)

On Class A flash file systems, you can configure the Cisco IOS software to load the startup configuration file specified by the CONFIG\_FILE environment variable. The CONFIG\_FILE variable defaults to NVRAM. To change the CONFIG\_FILE environment variable, complete the tasks in this section:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<p><b>copy</b> <i>[flash-url   ftp-url   rcp-url   tftp-url   system:running-config   nvram:startup-config]</i> <i>dest-flash-url</i></p> <p><b>Example:</b></p> <pre>Device# copy system:running-config nvram:startup-config</pre>	<p>Copies the configuration file to the flash file system from which the device loads the file on restart.</p>
<b>Step 3</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	<p>Enters global configuration mode.</p>



	Command or Action	Purpose
<b>Step 4</b>	<b>boot config</b> <i>dest-flash-url</i> <b>Example:</b>  Device(config)# boot config 172.16.1.1	Sets the CONFIG_FILE environment variable. This step modifies the runtime CONFIG_FILE environment variable.
<b>Step 5</b>	<b>end</b> <b>Example:</b>  Device(config)# end	Exits global configuration mode.
<b>Step 6</b>	<b>copy system:running-config nvram:startup-config</b> <b>Example:</b>  Device# copy system:running-config nvram:startup-config	Saves the configuration performed in Step 3 to the startup configuration.
<b>Step 7</b>	<b>show boot</b> <b>Example:</b>  Device# show boot	(Optional) Allows you to verify the contents of the CONFIG_FILE environment variable.

### Examples

The following example copies the running configuration file to the device. This configuration is then used as the startup configuration when the system is restarted:

```
Device# copy system:running-config usbflash0:config2
Device# configure terminal
Device(config)# boot config usbflash0:config2
Device(config)# end
Device# copy system:running-config nvram:startup-config
[ok]
Device# show boot
BOOT variable = usbflash0:rsp-boot-m
CONFIG_FILE variable = nvram:
Current CONFIG_FILE variable = usbflash0:config2
Configuration register is 0x010F
```

## What to Do Next

After you specify a location for the startup configuration file, the **nvram:startup-config** command is aliased to the new location of the startup configuration file. The **more nvram:startup-config EXEC** command displays the startup configuration, regardless of its location. The **erase nvram:startup-config EXEC** command erases the contents of NVRAM and deletes the file pointed to by the CONFIG\_FILE environment variable.

When you save the configuration using the **copy system:running-config nvram:startup-config** command, the device saves a complete version of the configuration file to the location specified by the CONFIG\_FILE environment variable and a distilled version to NVRAM. A distilled version is one that does not contain access

list information. If NVRAM contains a complete configuration file, the device prompts you to confirm your overwrite of the complete version with the distilled version. If NVRAM contains a distilled configuration, the device does not prompt you for confirmation and proceeds with overwriting the existing distilled configuration file in NVRAM.



**Note** If you specify a file in a flash device as the CONFIG\_FILE environment variable, every time you save your configuration file with the **copy system:running-config nvram:startup-config** command, the old configuration file is marked as “deleted,” and the new configuration file is saved to that device. Eventually, Flash memory fills up as the old configuration files still take up memory. Use the **squeeze EXEC** command to permanently delete the old configuration files and reclaim the space.

## Configuring the Device to Download Configuration Files

You can specify an ordered list of network configuration and host configuration filenames. The Cisco IOS XE software scans this list until it loads the appropriate network or host configuration file.

To configure the device to download configuration files at system startup, perform at least one of the tasks described in the following sections:

- [Configuring the Device to Download the Network Configuration File \(CLI\)](#)
- [Configuring the Device to Download the Host Configuration File \(CLI\)](#)

If the device fails to load a configuration file during startup, it tries again every 10 minutes (the default setting) until a host provides the requested files. With each failed attempt, the device displays the following message on the console terminal:

```
Booting host-config... [timed out]
```

If there are any problems with the startup configuration file, or if the configuration register is set to ignore NVRAM, the device enters the Setup command facility.

### Configuring the Device to Download the Network Configuration File (CLI)

To configure the Cisco IOS software to download a network configuration file from a server at startup, complete the tasks in this section:

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# configure terminal	
<b>Step 3</b>	<p><b>boot network</b> {ftp:[[[//[username [:password ]@]location ]/directory ]/filename ]   rcp:[[[//[username@]location ]/directory ]/filename ]   tftp:[[[//[location ]/directory ]/filename ]}</p> <p><b>Example:</b></p> <pre>Device(config)# boot network tftp:hostfile1</pre>	<p>Specifies the network configuration file to download at startup, and the protocol to be used (TFTP, RCP, or FTP).</p> <ul style="list-style-type: none"> <li>If you do not specify a network configuration filename, the Cisco IOS software uses the default filename network-config. If you omit the address, the device uses the broadcast address.</li> <li>You can specify more than one network configuration file. The software tries them in order entered until it loads one. This procedure can be useful for keeping files with different configuration information loaded on a network server.</li> </ul>
<b>Step 4</b>	<p><b>service config</b></p> <p><b>Example:</b></p> <pre>Device(config)# service config</pre>	Enables the system to automatically load the network file on restart.
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Exits global configuration mode.
<b>Step 6</b>	<p><b>copy system:running-config nvram:startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy system:running-config nvram:startup-config</pre>	Saves the running configuration to the startup configuration file.

## Configuring the Device to Download the Host Configuration File (CLI)

To configure the Cisco IOS software to download a host configuration file from a server at startup, complete the tasks in this section:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>boot host</b> { <b>ftp</b> :[[[/ <i>username</i> [ <i>:password</i> ]@] <i>location</i> ]/ <i>directory</i> ]/ <i>filename</i> ]   <b>rep</b> :[[[/ <i>username</i> @] <i>location</i> ]/ <i>directory</i> ]/ <i>filename</i> ]   <b>tftp</b> :[[[/ <i>location</i> ]/ <i>directory</i> ]/ <i>filename</i> ] } <b>Example:</b> <pre>Device(config)# boot host tftp:hostfile1</pre>	<p>Specifies the host configuration file to download at startup, and the protocol to be used (FTP, RCP, or TFTP):</p> <ul style="list-style-type: none"> <li>• If you do not specify a host configuration filename, the device uses its own name to form a host configuration filename by converting the name to all lowercase letters, removing all domain information, and appending “-cfg.” If no host name information is available, the software uses the default host configuration filename device-cfg. If you omit the address, the device uses the broadcast address.</li> <li>• You can specify more than one host configuration file. The Cisco IOS software tries them in order entered until it loads one. This procedure can be useful for keeping files with different configuration information loaded on a network server.</li> </ul>
<b>Step 4</b>	<b>service config</b> <b>Example:</b> <pre>Device(config)# service config</pre>	Enables the system to automatically load the host file upon restart.
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Exits global configuration mode.
<b>Step 6</b>	<b>copy system:running-config nvram:startup-config</b> <b>Example:</b> <pre>Device# copy system:running-config nvram:startup-config</pre>	Saves the running configuration to the startup configuration file.

**Example**

In the following example, a device is configured to download the host configuration file named `hostfile1` and the network configuration file named `networkfile1`. The device uses TFTP and the broadcast address to obtain the file:

```
Device# configure terminal
Device(config)# boot host tftp:hostfile1
Device(config)# boot network tftp:networkfile1
Device(config)# service config
Device(config)# end
Device# copy system:running-config nvram:startup-config
```

## Additional References

**Related Documents**

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
Cisco IOS configuration commands	<i>Cisco IOS Configuration Fundamentals Command Reference</i>

**Error Message Decoder**

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**Standards**

Standard	Title
No new or modified standards are supported, and support for existing standards has not been modified	--

**MIBs**

MIB	MIBs Link
<ul style="list-style-type: none"> <li>No new or modified MIBs are supported, and support for existing MIBs has not been modified.</li> </ul>	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**RFCs**

RFC	Title
No new or modified RFCs are supported, and support for existing RFCs has not been modified.	--

**Technical Assistance**

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>



## CHAPTER 148

# Configuration Replace and Configuration Rollback

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- [Prerequisites for Configuration Replace and Configuration Rollback, on page 2681](#)
- [Restrictions for Configuration Replace and Configuration Rollback, on page 2682](#)
- [Information About Configuration Replace and Configuration Rollback, on page 2682](#)
- [How to Use Configuration Replace and Configuration Rollback, on page 2685](#)
- [Configuration Examples for Configuration Replace and Configuration Rollback, on page 2691](#)
- [Additional References, on page 2693](#)

## Prerequisites for Configuration Replace and Configuration Rollback

The format of the configuration files used as input by the Configuration Replace and Configuration Rollback feature must comply with standard Cisco software configuration file indentation rules as follows:

- Start all commands on a new line with no indentation, unless the command is within a configuration submode.
- Indent commands within a first-level configuration submode one space.
- Indent commands within a second-level configuration submode two spaces.
- Indent commands within subsequent submodes accordingly.

These indentation rules describe how the software creates configuration files for such commands as **show running-config** or **copy running-config destination-url**. Any configuration file generated on a Cisco device complies with these rules.

Free memory larger than the combined size of the two configuration files (the current running configuration and the saved replacement configuration) is required.

# Restrictions for Configuration Replace and Configuration Rollback

If the device does not have free memory larger than the combined size of the two configuration files (the current running configuration and the saved replacement configuration), the configuration replace operation is not performed.

Certain Cisco configuration commands such as those pertaining to physical components of a networking device (for example, physical interfaces) cannot be added or removed from the running configuration. For example, a configuration replace operation cannot remove the **interface ethernet 0** command line from the current running configuration if that interface is physically present on the device. Similarly, the **interface ethernet 1** command line cannot be added to the running configuration if no such interface is physically present on the device. A configuration replace operation that attempts to perform these types of changes results in error messages indicating that these specific command lines failed.

In very rare cases, certain Cisco configuration commands cannot be removed from the running configuration without reloading the device. A configuration replace operation that attempts to remove this type of command results in error messages indicating that these specific command lines failed.

## Information About Configuration Replace and Configuration Rollback

### Configuration Archive

The Cisco IOS configuration archive is intended to provide a mechanism to store, organize, and manage an archive of Cisco IOS configuration files to enhance the configuration rollback capability provided by the **configure replace** command. Before this feature was introduced, you could save copies of the running configuration using the **copy running-config destination-url** command, storing the replacement file either locally or remotely. However, this method lacked any automated file management. On the other hand, the Configuration Replace and Configuration Rollback feature provides the capability to automatically save copies of the running configuration to the Cisco IOS configuration archive. These archived files serve as checkpoint configuration references and can be used by the **configure replace** command to revert to previous configuration states.

The **archive config** command allows you to save Cisco IOS configurations in the configuration archive using a standard location and filename prefix that is automatically appended with an incremental version number (and optional timestamp) as each consecutive file is saved. This functionality provides a means for consistent identification of saved Cisco IOS configuration files. You can specify how many versions of the running configuration are kept in the archive. After the maximum number of files are saved in the archive, the oldest file is automatically deleted when the next, most recent file is saved. The **show archive** command displays information for all configuration files saved in the Cisco IOS configuration archive.

The Cisco IOS configuration archive, in which the configuration files are stored and available for use with the **configure replace** command, can be located on the following file systems: FTP, HTTP, RCP, TFTP.



## Configuration Replace

The **configure replace** privileged EXEC command provides the capability to replace the current running configuration with any saved Cisco IOS configuration file. This functionality can be used to revert to a previous configuration state, effectively rolling back any configuration changes that were made since the previous configuration state was saved.

When using the **configure replace** command, you must specify a saved Cisco IOS configuration as the replacement configuration file for the current running configuration. The replacement file must be a complete configuration generated by a Cisco IOS device (for example, a configuration generated by the **copy running-config destination-url** command), or, if generated externally, the replacement file must comply with the format of files generated by Cisco IOS devices. When the **configure replace** command is entered, the current running configuration is compared with the specified replacement configuration and a set of diffs is generated. The algorithm used to compare the two files is the same as that employed by the **show archive config differences** command. The resulting diffs are then applied by the Cisco IOS parser to achieve the replacement configuration state. Only the diffs are applied, avoiding potential service disruption from reapplying configuration commands that already exist in the current running configuration. This algorithm effectively handles configuration changes to order-dependent commands (such as access lists) through a multiple pass process. Under normal circumstances, no more than three passes are needed to complete a configuration replace operation, and a limit of five passes is performed to preclude any looping behavior.

The Cisco IOS **copy source-url running-config** privileged EXEC command is often used to copy a stored Cisco IOS configuration file to the running configuration. When using the **copy source-url running-config** command as an alternative to the **configure replace target-url** privileged EXEC command, the following major differences should be noted:

- The **copy source-url running-config** command is a merge operation and preserves all of the commands from both the source file and the current running configuration. This command does not remove commands from the current running configuration that are not present in the source file. In contrast, the **configure replace target-url** command removes commands from the current running configuration that are not present in the replacement file and adds commands to the current running configuration that need to be added.
- The **copy source-url running-config** command applies every command in the source file, whether or not the command is already present in the current running configuration. This algorithm is inefficient and, in some cases, can result in service outages. In contrast, the **configure replace target-url** command only applies the commands that need to be applied—no existing commands in the current running configuration are reapplied.
- A partial configuration file may be used as the source file for the **copy source-url running-config** command, whereas a complete Cisco IOS configuration file must be used as the replacement file for the **configure replace target-url** command.

A locking feature for the configuration replace operation was introduced. When the **configure replace** command is used, the running configuration file is locked by default for the duration of the configuration replace operation. This locking mechanism prevents other users from changing the running configuration while the replacement operation is taking place, which might otherwise cause the replacement operation to terminate unsuccessfully. You can disable the locking of the running configuration by using the **no lock** keyword when issuing the **configure replace** command.

The running configuration lock is automatically cleared at the end of the configuration replace operation. You can display any locks that may be currently applied to the running configuration using the **show configuration lock** command.

## Configuration Rollback

The concept of rollback comes from the transactional processing model common to database operations. In a database transaction, you might make a set of changes to a given database table. You then must choose whether to commit the changes (apply the changes permanently) or to roll back the changes (discard the changes and revert to the previous state of the table). In this context, rollback means that a journal file containing a log of the changes is discarded, and no changes are applied. The result of the rollback operation is to revert to the previous state, before any changes were applied.

The **configure replace** command allows you to revert to a previous configuration state, effectively rolling back changes that were made since the previous configuration state was saved. Instead of basing the rollback operation on a specific set of changes that were applied, the Cisco IOS configuration rollback capability uses the concept of reverting to a specific configuration state based on a saved Cisco IOS configuration file. This concept is similar to the database idea of saving a checkpoint (a saved version of the database) to preserve a specific state.

If the configuration rollback capability is desired, you must save the Cisco IOS running configuration before making any configuration changes. Then, after entering configuration changes, you can use that saved configuration file to roll back the changes (using the **configure replace target-url** command). Furthermore, because you can specify any saved Cisco IOS configuration file as the replacement configuration, you are not limited to a fixed number of rollbacks, as is the case in some rollback models.

### Configuration Rollback Confirmed Change

The Configuration Rollback Confirmed Change feature allows configuration changes to be performed with an optional requirement that they be confirmed. If this confirmation is not received, the configuration is returned to the state prior to the changes being applied. The mechanism provides a safeguard against inadvertent loss of connectivity between a network device and the user or management application due to configuration changes.

## Benefits of Configuration Replace and Configuration Rollback

- Allows you to revert to a previous configuration state, effectively rolling back configuration changes.
- Allows you to replace the current running configuration file with the startup configuration file without having to reload the device or manually undo CLI changes to the running configuration file, therefore reducing system downtime.
- Allows you to revert to any saved Cisco IOS configuration state.
- Simplifies configuration changes by allowing you to apply a complete configuration file to the device, where only the commands that need to be added or removed are affected.
- When using the **configure replace** command as an alternative to the **copy source-url running-config** command, increases efficiency and prevents risk of service outages by not reapplying existing commands in the current running configuration.

# How to Use Configuration Replace and Configuration Rollback

## Creating a Configuration Archive (CLI)

No prerequisite configuration is needed to use the **configure replace** command. Using the **configure replace** command in conjunction with the Cisco IOS configuration archive and the **archive config** command is optional but offers significant benefit for configuration rollback scenarios. Before using the **archive config** command, the configuration archive must be configured. Perform this task to configure the characteristics of the configuration archive.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>archive</b> <b>Example:</b> Device(config)# archive	Enters archive configuration mode.
<b>Step 4</b>	<b>path <i>url</i></b> <b>Example:</b> Device(config-archive)# path flash:myconfiguration	Specifies the location and filename prefix for the files in the Cisco IOS configuration archive. <p><b>Note</b> If a directory is specified in the path instead of file, the directory name must be followed by a forward slash as follows: path flash:/directory/. The forward slash is not necessary after a filename; it is only necessary when specifying a directory.</p>
<b>Step 5</b>	<b>maximum <i>number</i></b> <b>Example:</b> Device(config-archive)# maximum 14	(Optional) Sets the maximum number of archive files of the running configuration to be saved in the Cisco IOS configuration archive. <ul style="list-style-type: none"> <li>• The <i>number</i> argument is the maximum number of archive files of the running configuration to be saved in the Cisco IOS configuration archive. Valid values are from 1 to 14. The default is 10.</li> </ul>

	Command or Action	Purpose
		<p><b>Note</b> Before using this command, you must configure the <b>path</b> command to specify the location and filename prefix for the files in the Cisco IOS configuration archive.</p>
<b>Step 6</b>	<p><b>time-period</b> <i>minutes</i></p> <p><b>Example:</b></p> <pre>Device(config-archive)# time-period 1440</pre>	<p>(Optional) Sets the time increment for automatically saving an archive file of the current running configuration in the Cisco IOS configuration archive.</p> <ul style="list-style-type: none"> <li>The <i>minutes</i> argument specifies how often, in minutes, to automatically save an archive file of the current running configuration in the Cisco IOS configuration archive.</li> </ul> <p><b>Note</b> Before using this command, you must configure the <b>path</b> command to specify the location and filename prefix for the files in the Cisco IOS configuration archive.</p>
<b>Step 7</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-archive)# end</pre>	Exits to privileged EXEC mode.
<b>Step 8</b>	<p><b>archive config</b></p> <p><b>Example:</b></p> <pre>Device# archive config</pre>	<p>Saves the current running configuration file to the configuration archive.</p> <p><b>Note</b> The <b>path</b> command must be configured before using this command.</p>

## Performing a Configuration Replace or Configuration Rollback Operation (CLI)

Perform this task to replace the current running configuration file with a saved Cisco IOS configuration file.



### Note

You must create a configuration archive before performing this procedure. See [Creating a Configuration Archive \(CLI\)](#) for detailed steps. The following procedure details how to return to that archived configuration in the event of a problem with the current running configuration.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Device&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<p><b>configure replace</b> <i>target-url</i> [<b>nolock</b>] [<b>list</b>] [<b>force</b>] [<b>ignore case</b>] [<b>revert trigger</b> [<b>error</b>] ] [<b>timer</b> <i>minutes</i>]   <b>time</b> <i>minutes</i> ]</p> <p><b>Example:</b></p> <pre>Device# configure replace flash: startup-config time 120</pre>	<p>Replaces the current running configuration file with a saved Cisco IOS configuration file.</p> <ul style="list-style-type: none"> <li>• The <i>target - url</i> argument is a URL (accessible by the Cisco IOS file system) of the saved Cisco IOS configuration file that is to replace the current running configuration, such as the configuration file created using the <b>archive config</b> command.</li> <li>• The <b>list</b> keyword displays a list of the command lines applied by the Cisco IOS software parser during each pass of the configuration replace operation. The total number of passes performed is also displayed.</li> <li>• The <b>force</b> keyword replaces the current running configuration file with the specified saved Cisco IOS configuration file without prompting you for confirmation.</li> <li>• The <b>time</b> <i>minutes</i> keyword and argument specify the time (in minutes) within which you must enter the <b>configure confirm</b> command to confirm replacement of the current running configuration file. If the <b>configure confirm</b> command is not entered within the specified time limit, the configuration replace operation is automatically reversed (in other words, the current running configuration file is restored to the configuration state that existed prior to entering the <b>configure replace</b> command).</li> <li>• The <b>nolock</b> keyword disables the locking of the running configuration file that prevents other users from changing the running configuration during a configuration replace operation.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>The <b>revert trigger</b> keywords set the following triggers for reverting to the original configuration: <ul style="list-style-type: none"> <li><b>error</b> —Reverts to the original configuration upon error.</li> <li><b>timer <i>minutes</i></b> —Reverts to the original configuration if specified time elapses.</li> </ul> </li> <li>The <b>ignore case</b> keyword allows the configuration to ignore the case of the confirmation command.</li> </ul>
<b>Step 3</b>	<p><b>configure revert</b> { <b>now</b>   <b>timer</b> { <i>minutes</i>   <b>idle</b> <i>minutes</i> } }</p> <p><b>Example:</b></p> <pre>Device# configure revert now</pre>	<p>(Optional) To cancel the timed rollback and trigger the rollback immediately, or to reset parameters for the timed rollback, use the <b>configure revert</b> command in privileged EXEC mode.</p> <ul style="list-style-type: none"> <li><b>now</b> —Triggers the rollback immediately.</li> <li><b>timer</b> —Resets the configuration revert timer. <ul style="list-style-type: none"> <li>Use the <i>minutes</i> argument with the <b>timer</b> keyword to specify a new revert time in minutes.</li> <li>Use the <b>idle</b> keyword along with a time in minutes to set the maximum allowable time period of no activity before reverting to the saved configuration.</li> </ul> </li> </ul>
<b>Step 4</b>	<p><b>configure confirm</b></p> <p><b>Example:</b></p> <pre>Device# configure confirm</pre>	<p>(Optional) Confirms replacement of the current running configuration file with a saved Cisco IOS configuration file.</p> <p><b>Note</b> Use this command only if the <b>time <i>seconds</i></b> keyword and argument of the <b>configure replace</b> command are specified.</p>
<b>Step 5</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device# exit</pre>	Exits to user EXEC mode.

## Monitoring and Troubleshooting the Feature (CLI)

Perform this task to monitor and troubleshoot the Configuration Replace and Configuration Rollback feature.

### Procedure

---

#### Step 1 enable

Use this command to enable privileged EXEC mode. Enter your password if prompted.

#### Example:

```
Device> enable
Device#
```

#### Step 2 show archive

Use this command to display information about the files saved in the Cisco IOS configuration archive.

#### Example:

```
Device# show archive
There are currently 1 archive configurations saved.
The next archive file will be named flash:myconfiguration-2
Archive # Name
0
1 flash:myconfiguration-1 <- Most Recent
2
3
4
5
6
7
8
9
10
11
12
13
14
```

The following is sample output from the **show archive** command after several archive files of the running configuration have been saved. In this example, the maximum number of archive files to be saved is set to three.

#### Example:

```
Device# show archive
There are currently 3 archive configurations saved.
The next archive file will be named flash:myconfiguration-8
Archive # Name
0
1 :Deleted
2 :Deleted
3 :Deleted
4 :Deleted
5 flash:myconfiguration-5
6 flash:myconfiguration-6
7 flash:myconfiguration-7 <- Most Recent
```

```

8
9
10
11
12
13
14

```

### Step 3 debug archive versioning

Use this command to enable debugging of the Cisco IOS configuration archive activities to help monitor and troubleshoot configuration replace and rollback.

#### Example:

```

Device# debug archive versioning
Jan  9 06:46:28.419:backup_running_config
Jan  9 06:46:28.419:Current = 7
Jan  9 06:46:28.443:Writing backup file flash:myconfiguration-7
Jan  9 06:46:29.547: backup worked

```

### Step 4 debug archive config timestamp

Use this command to enable debugging of the processing time for each integral step of a configuration replace operation and the size of the configuration files being handled.

#### Example:

```

Device# debug archive config timestamp
Device# configure replace flash:myconfiguration force
Timing Debug Statistics for IOS Config Replace operation:
  Time to read file usbflash0:sample_2.cfg = 0 msec (0 sec)
  Number of lines read:55
  Size of file           :1054
Starting Pass 1
  Time to read file system:running-config = 0 msec (0 sec)
  Number of lines read:93
  Size of file           :2539
  Time taken for positive rollback pass = 320 msec (0 sec)
  Time taken for negative rollback pass = 0 msec (0 sec)
  Time taken for negative incremental diffs pass = 59 msec (0 sec)
  Time taken by PI to apply changes = 0 msec (0 sec)
  Time taken for Pass 1 = 380 msec (0 sec)
Starting Pass 2
  Time to read file system:running-config = 0 msec (0 sec)
  Number of lines read:55
  Size of file           :1054
  Time taken for positive rollback pass = 0 msec (0 sec)
  Time taken for negative rollback pass = 0 msec (0 sec)
  Time taken for Pass 2 = 0 msec (0 sec)
Total number of passes:1
Rollback Done

```

### Step 5 exit

Use this command to exit to user EXEC mode.

#### Example:



```
Device# exit
Device>
```

## Configuration Examples for Configuration Replace and Configuration Rollback

### Creating a Configuration Archive

The following example shows how to perform the initial configuration of the Cisco IOS configuration archive. In this example, `flash:myconfiguration` is specified as the location and filename prefix for the files in the configuration archive and a value of 10 is set as the maximum number of archive files to be saved.

```
configure terminal
!
archive
 path flash:myconfiguration
 maximum 10
end
```

### Replacing the Current Running Configuration with a Saved Cisco IOS Configuration File

The following example shows how to replace the current running configuration with a saved Cisco IOS configuration file named `flash:myconfiguration`. The **configure replace** command interactively prompts you to confirm the operation.

```
Device# configure replace flash:myconfiguration
This will apply all necessary additions and deletions
to replace the current running configuration with the
contents of the specified configuration file, which is
assumed to be a complete configuration, not a partial
configuration. Enter Y if you are sure you want to proceed. ? [no]: Y
Total number of passes: 1
Rollback Done
```

In the following example, the **list** keyword is specified in order to display the command lines that were applied during the configuration replace operation:

```
Device# configure replace flash:myconfiguration list
This will apply all necessary additions and deletions
to replace the current running configuration with the
contents of the specified configuration file, which is
assumed to be a complete configuration, not a partial
configuration. Enter Y if you are sure you want to proceed. ? [no]: Y
!Pass 1
!List of Commands:
no snmp-server community public ro
```

```
snmp-server community mystring ro

end
Total number of passes: 1
Rollback Done
```

## Reverting to the Startup Configuration File

The following example shows how to revert to the Cisco IOS startup configuration file using the **configure replace** command. This example also shows the use of the optional **force** keyword to override the interactive user prompt:

```
Device# configure replace flash:startup-config force
Total number of passes: 1
Rollback Done
```

## Performing a Configuration Replace Operation with the **configure confirm** Command

The following example shows the use of the **configure replace** command with the **time minutes** keyword and argument. You must enter the **configure confirm** command within the specified time limit to confirm replacement of the current running configuration file. If the **configure confirm** command is not entered within the specified time limit, the configuration replace operation is automatically reversed (in other words, the current running configuration file is restored to the configuration state that existed prior to entering the **configure replace** command).

```
Device# configure replace flash:startup-config time 120
This will apply all necessary additions and deletions
to replace the current running configuration with the
contents of the specified configuration file, which is
assumed to be a complete configuration, not a partial
configuration. Enter Y if you are sure you want to proceed. ? [no]: Y
Total number of passes: 1
Rollback Done
Device# configure confirm
```

The following example shows the use of the **configure revert** command with the **timer** keyword. You must enter the **configure revert** command to cancel the timed rollback and trigger the rollback immediately, or to reset parameters for the timed rollback.

```
Device# configure revert timer 100
```

## Performing a Configuration Rollback Operation

The following example shows how to make changes to the current running configuration and then roll back the changes. As part of the configuration rollback operation, you must save the current running configuration before making changes to the file. In this example, the **archive config** command is used to save the current running configuration. The generated output of the **configure replace** command indicates that only one pass was performed to complete the rollback operation.



**Note** Before using the **archive config** command, you must configure the **path** command to specify the location and filename prefix for the files in the Cisco IOS configuration archive.

You first save the current running configuration in the configuration archive as follows:

```
archive config
```

You then enter configuration changes as shown in the following example:

```
configure terminal
!
user netops2 password rain
user netops3 password snow
exit
```

After having made changes to the running configuration file, assume you now want to roll back these changes and revert to the configuration that existed before the changes were made. The **show archive** command is used to verify the version of the configuration to be used as a replacement file. The **configure replace** command is then used to revert to the replacement configuration file as shown in the following example:

```
Device# show archive
There are currently 1 archive configurations saved.
The next archive file will be named flash:myconfiguration-2
Archive # Name
0
1 flash:myconfiguration-1 <- Most Recent
2
3
4
5
6
7
8
9
10
Device# configure replace flash:myconfiguration-1
Total number of passes: 1
Rollback Done
```

## Additional References

### Related Documents

Related Topic	Document Title
Configuration Locking	<i>Exclusive Configuration Change Access and Access Session Locking</i>
Commands for managing configuration files	<i>Cisco IOS Configuration Fundamentals Command Reference</i>

Related Topic	Document Title
Information about managing configuration files	<i>Managing Configuration Files</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	--

### MIBs

MIBs	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	--

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<p><a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a></p>





## CHAPTER 149

# Working with the Flash File System

- [Information About the Flash File System, on page 2697](#)
- [Displaying Available File Systems, on page 2697](#)
- [Setting the Default File System, on page 2700](#)
- [Displaying Information About Files on a File System, on page 2700](#)
- [Changing Directories and Displaying the Working Directory \(CLI\), on page 2701](#)
- [Creating Directories \(CLI\), on page 2702](#)
- [Copying Files, on page 2703](#)
- [Creating, Displaying and Extracting Files \(CLI\), on page 2705](#)
- [Additional References, on page 2707](#)

## Information About the Flash File System

The flash file system is a single flash device on which you can store files. It also provides several commands to help you manage software bundles and configuration files. The default flash file system on the device is named flash:

As viewed from the active device, flash: refers to the local flash device, which is the device attached to the same device on which the file system is being viewed. In a device stack, each of the flash devices from the various stack members can be viewed from the active device. The names of these flash file systems include the corresponding device member numbers. For example, flash-3:, as viewed from the active device, refers to the same file system as does flash: on stack member 3. Use the **show file systems** privileged EXEC command to list all file systems, including the flash file systems in the device stack.

Only one user at a time can manage the software bundles and configuration files for a device stack .

## Displaying Available File Systems

To display the available file systems on your device, use the **show file systems** privileged EXEC command as shown in this example for a standalone device:

```
Device# show file systems
File Systems:
  Size(b)      Free(b)      Type      Flags      Prefixes
*  15998976    5135872     flash     rw         flash:
      -         -           opaque    rw         bs:
      -         -           opaque    rw         vb:
```

## Displaying Available File Systems

```

524288      520138      nvram      rw      nvram:
-           -           network    rw      tftp:
-           -           opaque     rw      null:
-           -           opaque     rw      system:
-           -           opaque     ro      xmodem:
-           -           opaque     ro      ymodem:

```

This example shows a device stack. In this example, the active device is stack member 1; the file system on stack member 2 is displayed as flash-2; the file system on stack member 3 is displayed as flash-3; and so on up to stack member 9, displayed as flash-9: for a 9-member stack. The example also shows the crashinfo directories and a USB flash drive plugged into the active device:

```

Device# show file systems
File Systems:
  Size (b)      Free (b)      Type  Flags  Prefixes
145898496      5479424      disk  rw     crashinfo:crashinfo-1:
248512512      85983232     disk  rw     crashinfo-2:stby-crashinfo:
146014208      17301504     disk  rw     crashinfo-3:
146014208      0            disk  rw     crashinfo-4:
146014208      1572864      disk  rw     crashinfo-5:
248512512      30932992     disk  rw     crashinfo-6:
146014208      6291456      disk  rw     crashinfo-7:
146276352      15728640     disk  rw     crashinfo-8:
146276352      73400320     disk  rw     crashinfo-9:
* 741621760     481730560    disk  rw     flash:flash-1:
1622147072     1360527360   disk  rw     flash-2:stby-flash:
729546752     469762048    disk  rw     flash-3:
729546752     469762048    disk  rw     flash-4:
729546752     469762048    disk  rw     flash-5:
1622147072     1340604416   disk  rw     flash-6:
729546752     469762048    disk  rw     flash-7:
1749549056     1487929344   disk  rw     flash-8:
1749549056     1487929344   disk  rw     flash-9:
0              0            disk  rw     unix:
-              -            disk  rw     usbflash0:usbflash0-1:
-              -            disk  rw     usbflash0-2: stby-usbflash0:
-              -            disk  rw     usbflash0-3:
-              -            disk  rw     usbflash0-4:
-              -            disk  rw     usbflash0-5:
-              -            disk  rw     usbflash0-6:
-              -            disk  rw     usbflash0-7:
-              -            disk  rw     usbflash0-8:
-              -            disk  rw     usbflash0-9:
0              0            disk  ro     webui:
-              -            opaque rw     system:
-              -            opaque rw     tmpsys:
2097152       2055643      nvram  rw     stby-nvram:
-              -            nvram  rw     stby-rcsf:
-              -            opaque rw     null:
-              -            opaque ro     tar:
-              -            network rw     tftp:
2097152       2055643      nvram  rw     nvram:
-              -            opaque wo     syslog:
-              -            network rw     rcp:
-              -            network rw     http:
-              -            network rw     ftp:
-              -            network rw     scp:
-              -            network rw     https:
-              -            opaque ro     cns:
-              -            opaque rw     revrcsf:

```



Table 215: show file systems Field Descriptions

Field	Value
Size(b)	Amount of memory in the file system in bytes.
Free(b)	Amount of free memory in the file system in bytes.
Type	Type of file system. <b>disk</b> —The file system is for a flash memory device, USB flash, and crashinfo file. <b>network</b> —The file system for network devices; for example, an FTP server or and HTTP server. <b>nvr</b> am—The file system is for a NVRAM device. <b>opaque</b> —The file system is a locally generated pseudo file system (for example, the system) or a download interface, such as brimux. <b>unknown</b> —The file system is an unknown type.
Flags	Permission for file system. <b>ro</b> —read-only. <b>rw</b> —read/write. <b>wo</b> —write-only.

Field	Value
Prefixes	<p>Alias for file system.</p> <p><b>crashinfo:</b>—Crashinfo file.</p> <p><b>flash:</b>—Flash file system.</p> <p><b>ftp:</b>—FTP server.</p> <p><b>http:</b>—HTTP server.</p> <p><b>https:</b>—Secure HTTP server.</p> <p><b>nvr:</b>—NVRAM.</p> <p><b>null:</b>—Null destination for copies. You can copy a remote file to null to find its size.</p> <p><b>rcp:</b>—Remote Copy Protocol (RCP) server.</p> <p><b>scp:</b>—Session Control Protocol (SCP) server.</p> <p><b>system:</b>—Contains the system memory, including the running configuration.</p> <p><b>tftp:</b>—TFTP network server.</p> <p><b>usbflash0:</b>—USB flash memory.</p> <p><b>xmodem:</b>—Obtain the file from a network machine by using the Xmodem protocol.</p> <p><b>ymodem:</b>—Obtain the file from a network machine by using the Ymodem protocol.</p>

## Setting the Default File System

You can specify the file system or directory that the system uses as the default file system by using the **cd** *filesystem:* privileged EXEC command. You can set the default file system to omit the *filesystem:* argument from related commands. For example, for all privileged EXEC commands that have the optional *filesystem:* argument, the system uses the file system specified by the **cd** command.

By default, the default file system is *flash:*.

You can display the current default file system as specified by the **cd** command by using the **pwd** privileged EXEC command.

## Displaying Information About Files on a File System

You can view a list of the contents of a file system before manipulating its contents. For example, before copying a new configuration file to flash memory, you might want to verify that the file system does not already contain a configuration file with the same name. Similarly, before copying a flash configuration file to another location, you might want to verify its filename for use in another command. To display information about files on a file system, use one of the privileged EXEC commands listed in the following table.

Table 216: Commands for Displaying Information About Files

Command	Description
<b>dir</b> [/all] [filesystem:filename]	Displays a list of files on a file system.
<b>show file systems</b>	Displays more information about each of the files on a file system.
<b>show file information</b> file-url	Displays information about a specific file.
<b>show file descriptors</b>	Displays a list of open file descriptors. File descriptors are the internal representations of open files. You can use this command to see if another user has a file open.

For example, to display a list of all files in a file system, use the **dir** privileged EXEC command:

```
device# dir flash:
Directory of flash:/
7386  -rwx      2097152 Jan 23 2013 14:06:49 +00:00 nvram_config
7378  drwx         4096 Jan 23 2013 09:35:11 +00:00 mnt
7385  -rw-      221775876 Jan 23 2013 14:15:13 +00:00
cat3k_caa-universalk9.SSA.03.12.02.EZP.150-12.02.EZP.150-12.02.EZP.bin
7389  -rwx         556 Jan 21 2013 20:47:30 +00:00 vlan.dat
712413184 bytes total (445063168 bytes free)
device#
```

## Changing Directories and Displaying the Working Directory (CLI)

Follow these steps to change directories and to display the working directory:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>dir filesystem:</b> <b>Example:</b>  Device# dir flash:	Displays the directories on the specified file system.  For <i>filesystem:</i> , use flash: for the system board flash device.  To access flash partitions of device members in a stack, use flash- <i>n</i> where <i>n</i> is the stack member number. For example, flash-4.

	Command or Action	Purpose
<b>Step 3</b>	<b>cd</b> <i>directory_name</i>  <b>Example:</b>  Device# cd new_configs	Navigates to the specified directory.  The command example shows how to navigate to the directory named <i>new_configs</i> .
<b>Step 4</b>	<b>pwd</b>  <b>Example:</b>  Device# pwd	Displays the working directory.
<b>Step 5</b>	<b>cd</b>  <b>Example:</b>  Device# cd	Navigates to the default directory.

## Creating Directories (CLI)

Beginning in privileged EXEC mode, follow these steps to create a directory:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>dir</b> <i>filesystem:</i>  <b>Example:</b>  Device# dir flash:	Displays the directories on the specified file system.  For <i>filesystem:</i> , use flash: for the system board flash device.
<b>Step 2</b>	<b>mkdir</b> <i>directory_name</i>  <b>Example:</b>  Device# mkdir new_configs	Creates a new directory. Directory names are case sensitive and are limited to 45 characters between the slashes (/); the name cannot contain control characters, spaces, slashes, quotes, semicolons, or colons.
<b>Step 3</b>	<b>dir</b> <i>filesystem:</i>  <b>Example:</b>  Device# dir flash:	Verifies your entry.

## Removing Directories

To remove a directory with all its files and subdirectories, use the **delete /force /recursive** *filesystem:/file-url* privileged EXEC command.

Use the **/recursive** keyword to delete the named directory and all subdirectories and the files contained in it. Use the **/force** keyword to suppress the prompting that confirms a deletion of each file in the directory. You are prompted only once at the beginning of this deletion process.

For *filesystem*, use **flash:** for the system board flash device. For *file-url*, enter the name of the directory to be deleted. All of the files in the directory and the directory are removed.



---

**Caution** When directories are deleted, their contents cannot be recovered.

---

## Copying Files

To copy a file from a source to a destination, use the **copy source-url destination-url** privileged EXEC command. For the source and destination URLs, you can use **running-config** and **startup-config** keyword shortcuts. For example, the **copy running-config startup-config** command saves the currently running configuration file to the NVRAM section of flash memory to be used as the configuration during system initialization.

You can also copy from special file systems (**xmodem:**, **ymodem:**) as the source for the file from a network machine that uses the Xmodem or Ymodem protocol.

Network file system URLs include ftp:, rcp:, tftp:, scp:, http:, and https: and have these syntaxes:

- FTP—ftp:[[/username [:password]@location]/directory]/filename
- RCP—rcp:[[/username@location]/directory]/filename
- TFTP—tftp:[[/location]/directory]/filename
- SCP—scp:[[/username [:password]@location]/directory]/filename
- HTTP—http:[[/username [:password]@location]/directory]/filename
- HTTPS—https:[[/username [:password]@location]/directory]/filename



---

**Note** The password must not contain the special character '@'. If the character '@' is used, the copy fails to parse the IP address of the server.

---

Local writable file systems include flash:.

Some invalid combinations of source and destination exist. Specifically, you cannot copy these combinations:

- From a running configuration to a running configuration
- From a startup configuration to a startup configuration
- From a device to the same device (for example, the **copy flash: flash:** command is invalid)

## Copying Files from One Device in a Stack to Another Device in the Same Stack

To copy a file from one device in a stack to another device in the same stack, use the **flash-X:** notation, where **X** is the device number.

To view all devices in a stack, use the **show switch** command in privileged EXEC mode, as in the following example of a 9-member device stack:

```
Device# show switch
Switch/Stack Mac Address : 0006.f6b9.b580 - Local Mac Address Mac persistency wait time:
Indefinite
```

Switch#	Role	Mac Address	Priority	H/W Version	Current State
*1	Active	0006.f6b9.b580	15	P3B	Ready
2	Standby	0006.f6ba.0c80	14	P3B	Ready
3	Member	0006.f6ba.3300	7	P3B	Ready
4	Member	0006.f6b9.df80	6	P3B	Ready
5	Member	0006.f6ba.3880	13	P1A	Ready
6	Member	1ce6.c7b6.ef00	4	PP	Ready
7	Member	2037.06ce.2580	3	P2A	Ready
8	Member	2037.0653.7e00	2	P5A	Ready
9	Member	2037.0653.9280	1	P5B	Ready

To view all file systems available to copy on a specific device, use the **copy** command as in the following example of a 5-member stack:

```
Device# copy flash: ?
crashinfo-1: Copy to crashinfo-1: file system
crashinfo-2: Copy to crashinfo-2: file system
crashinfo-3: Copy to crashinfo-3: file system
crashinfo-4: Copy to crashinfo-4: file system
crashinfo-5: Copy to crashinfo-5: file system
crashinfo: Copy to crashinfo: file system
flash-1: Copy to flash-1: file system
flash-2: Copy to flash-2: file system
flash-3: Copy to flash-3: file system
flash-4: Copy to flash-4: file system
flash-5: Copy to flash-5: file system
flash: Copy to flash: file system
ftp: Copy to ftp: file system
http: Copy to http: file system
https: Copy to https: file system
null: Copy to null: file system
nvram: Copy to nvram: file system
rcp: Copy to rcp: file system
revrcsf: Copy to revrcsf: file system
running-config Update (merge with) current system configuration
scp: Copy to scp: file system
startup-config Copy to startup configuration
stby-crashinfo: Copy to stby-crashinfo: file system
stby-flash: Copy to stby-flash: file system
stby-nvram: Copy to stby-nvram: file system
stby-rcsf: Copy to stby-rcsf: file system
stby-usbflash0: Copy to stby-usbflash0: file system
syslog: Copy to syslog: file system
system: Copy to system: file system
tftp: Copy to tftp: file system
tmpsys: Copy to tmpsys: file system
usbflash0-1: Copy to usbflash0-1: file system
```

```
usbflash0-2:      Copy to usbflash0-2: file system
usbflash0-3:      Copy to usbflash0-3: file system
usbflash0-4:      Copy to usbflash0-4: file system
usbflash0-5:      Copy to usbflash0-5: file system
usbflash0:        Copy to usbflash0: file system
```

Device#

This example shows how to copy a config file stored in the flash partition of device 2 to the flash partition of device 4. It assumes that device 2 and device 4 are in the same stack.

```
Device# copy flash-2:config.txt flash-4:config.txt
```

## Deleting Files

When you no longer need a file on a flash memory device, you can permanently delete it. To delete a file or directory from a specified flash device, use the **delete** [**force**] [**recursive**] [*filesystem:*]/*file-url* privileged EXEC command.

Use the **/recursive** keyword for deleting a directory and all subdirectories and the files contained in it. Use the **/force** keyword to suppress the prompting that confirms a deletion of each file in the directory. You are prompted only once at the beginning of this deletion process. Use the **/force** and **/recursive** keywords for deleting old software images that were installed by using the **archive download-sw** command but are no longer needed.

If you omit the *filesystem:* option, the device uses the default device specified by the **cd** command. For *file-url*, you specify the path (directory) and the name of the file to be deleted.

When you attempt to delete any files, the system prompts you to confirm the deletion.



### Caution

When files are deleted, their contents cannot be recovered.

This example shows how to delete the file *myconfig* from the default flash memory device:

```
Device# delete myconfig
```

## Creating, Displaying and Extracting Files (CLI)

You can create a file and write files into it, list the files in a file, and extract the files from a file as described in the next sections.

Beginning in privileged EXEC mode, follow these steps to create a file, display the contents, and extract it:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>archive tar /create destination-url flash:</b> <i>/file-url</i>	Creates a file and adds files to it.

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>device# archive tar /create tftp:172.20.10.30/saved. flash:/new-configs</pre>	<p>For destination-url, specify the destination URL alias for the local or network file system and the name of the file to create:</p> <ul style="list-style-type: none"> <li>Local flash file system syntax: <p><b>flash:</b></p> </li> <li>FTP syntax: <p><b>ftp:</b>[[/username[password]@location]directory]/-filename.</p> </li> <li>RCP syntax: <p><b>rcp:</b>[[/username@location]directory]/-filename.</p> </li> <li>TFTP syntax: <p><b>tftp:</b>[[//location]directory]/-filename.</p> </li> </ul> <p>For <b>flash:/file-url</b>, specify the location on the local flash file system in which the new file is created. You can also specify an optional list of files or directories within the source directory to add to the new file. If none are specified, all files and directories at this level are written to the newly created file.</p>
<b>Step 2</b>	<p><b>archive tar /table source-url</b></p> <p><b>Example:</b></p> <pre>device# archive tar /table flash: /new_configs</pre>	<p>Displays the contents of a file.</p> <p>For <i>source-url</i>, specify the source URL alias for the local or network file system. The <i>-filename</i> is the file to display. These options are supported:</p> <ul style="list-style-type: none"> <li>Local flash file system syntax: <p><b>flash:</b></p> </li> <li>FTP syntax: <p><b>ftp:</b>[[/username[password]@location]directory]/-filename.</p> </li> <li>RCP syntax: <p><b>rcp:</b>[[/username@location]directory]/-filename.</p> </li> <li>TFTP syntax: <p><b>tftp:</b>[[//location]directory]/-filename.</p> </li> </ul> <p>You can also limit the file displays by specifying a list of files or directories after the file. Only those files appear. If none are specified, all files and directories appear.</p>
<b>Step 3</b>	<p><b>archive tar /xtract source-url flash:/file-url [dir/file...]</b></p> <p><b>Example:</b></p> <pre>device# archive tar /xtract</pre>	<p>Extracts a file into a directory on the flash file system.</p> <p>For <i>source-url</i>, specify the source URL alias for the local file system. The <i>-filename</i> is the</p>



	Command or Action	Purpose
	<pre>tftp://172.20.10.30/saved. flash:/new-configs</pre>	<p>file from which to extract files. These options are supported:</p> <ul style="list-style-type: none"> <li>Local flash file system syntax: <ul style="list-style-type: none"> <li><b>flash:</b></li> </ul> </li> <li>FTP syntax: <ul style="list-style-type: none"> <li><b>ftp:</b>[[/username[:password]@location]/directory]/filename.</li> </ul> </li> <li>RCP syntax: <ul style="list-style-type: none"> <li><b>rcp:</b>[[/username@location]/directory]/filename.</li> </ul> </li> <li>TFTP syntax: <ul style="list-style-type: none"> <li><b>tftp:</b>[[//location]/directory]/filename.</li> </ul> </li> </ul> <p>For <b>flash:/file-url</b> [dir/file...], specify the location on the local flash file system from which the file is extracted. Use the <i>dir/file...</i> option to specify a list of files or directories within the file to be extracted. If none are specified, all files and directories are extracted.</p>
<b>Step 4</b>	<p><b>more</b> [ /ascii   /binary   /ebcdic ] /file-url</p> <p><b>Example:</b></p> <pre>device# more flash:/new-configs</pre>	Displays the contents of any readable file, including a file on a remote file system.

## Additional References

### Related Documents

Related Topic	Document Title
Commands for managing flash: file systems	<i>Cisco IOS Configuration Fundamentals Command Reference</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**Standards**

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	--

**MIBs**

MIBs	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**RFCs**

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	--

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>



## CHAPTER **150**

# Upgrading the Switch Software

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- [Upgrading the Switch Software, on page 2709](#)

## Upgrading the Switch Software

For information about upgrading the switch software from Cisco IOS XE Release 3.x.x to Cisco IOS XE Denali 16.1.x, see [Release Notes for Cisco Catalyst 3850 Series Switch, Cisco IOS XE Denali 16.1.x](#).





## CHAPTER 151

# Conditional Debug and Radioactive Tracing

- [Finding Feature Information, on page 2711](#)
- [Introduction to Conditional Debugging, on page 2711](#)
- [Introduction to Radioactive Tracing, on page 2712](#)
- [Conditional Debugging and Radioactive Tracing, on page 2712](#)
- [Location of Tracefiles, on page 2713](#)
- [Configuring Conditional Debugging, on page 2713](#)
- [Radioactive Tracing for L2 Multicast, on page 2715](#)
- [Recommended Workflow for Trace files, on page 2715](#)
- [Copying tracefiles off the box, on page 2716](#)
- [Configuration Examples for Conditional Debugging, on page 2717](#)
- [Monitoring Conditional Debugging, on page 2717](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Introduction to Conditional Debugging

The Conditional Debugging feature allows you to selectively enable debugging and logging for specific features based on the set of conditions you define. This feature is useful in systems where a large number of features are supported.



---

**Note** In Cisco IOS XE Denali 16.1.1, only Control Plane Tracing is supported.

---

The Conditional debug allows granular debugging in a network that is operating at a large scale with a large number of features. It allows you to observe detailed debugs for granular instances within the system. This is very useful when we need to debug only a particular session among thousands of sessions. It is also possible to specify multiple conditions.

A condition refers to a feature or identity, where identity could be an interface, IP Address, or a MAC address and so on.



---

**Note** In Cisco IOS XE Denali 16.1.1, MAC address is the only supported condition. The support for other features will be introduced in the releases that follow.

---

This is in contrast to the general debug command, that produces its output without discriminating on the feature objects that are being processed. General debug command consumes a lot of system resources and impacts the system performance.



---

**Note** To enable debug for wireless IPs, use the **debug platform condition feature wireless ip ip-address** command.

---

## Introduction to Radioactive Tracing

Radioactive tracing provides the ability to stitch together a chain of execution for operations of interest across the system, at an increased verbosity level. This provides a way to conditionally print debug information (up to DEBUG Level or a specified level) across threads, processes and function calls.



---

**Note** In Cisco IOS XE Denali 16.1.1 the default level is **DEBUG**. The users cannot change this to another level. The support for other levels will be introduced in the releases that follow.

---



---

**Note** The radioactive tracing supports First-Hop Security (FHS).

For more information on First Hop Security features, see *System Management > Wireless Multicast > Information About Wireless Multicast > Information About IPv6 Snooping*.

---

## Conditional Debugging and Radioactive Tracing

Radioactive Tracing when coupled with Conditional Debugging, enable us to have a single debug CLI to debug all execution contexts related to the condition. This can be done without being aware of the various control flow processes of the feature within the box and without having to issue debugs at these processes individually.

## Location of Tracefiles

By default the tracefile logs will be generated for each process and saved into either the **/tmp/rp/trace** or **/tmp/fp/trace** directory. In this temp directory, the trace logs are written to files, which are of 1 MB size each. The directory can hold up to a maximum of 25 such files for a given process. When a tracefile in the **/tmp** directory reaches its 1MB limit or whatever size was configured for it during the boot time, it is rotated out to an archive location in the **/crashinfo** partition under **tracelogs** directory.

The **/tmp** directory holds only a single tracefile for a given process. Once the file reaches its file size limit it is rotated out to **/crashinfo/tracelogs**. In the archive directory, up to 25 files are accumulated, after which the oldest one is replaced by the newly rotated file from **/tmp**.

The tracefiles in the crashinfo directory are located in the following formats:

1. Process-name\_Process-ID\_running-counter.timestamp.gz  
Example: IOSRP\_R0-0.bin\_0.14239.20151101234827.gz
2. Process-name\_pmanlog\_Process-ID\_running-counter.timestamp.bin.gz  
Example: wcm\_pmanlog\_R0-0.30360\_0.20151028233007.bin.gz

## Configuring Conditional Debugging

To configure conditional debugging, follow the steps given below:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>debug platform condition mac {mac-address}</b> <b>Example:</b> Device# <b>debug platform condition mac bc16.6509.3314</b>	Configures conditional debugging for the MAC Address specified.
<b>Step 3</b>	<b>debug platform condition start</b> <b>Example:</b> Device# <b>debug platform condition start</b>	Starts conditional debugging (this will start radioactive tracing if there is a match on one of the conditions above).
<b>Step 4</b>	<b>show platform condition OR show debug</b> <b>Example:</b> Device# <b>show platform condition</b> Device# <b>show debug</b>	Displays the current conditions set.

	Command or Action	Purpose
<b>Step 5</b>	<b>debug platform condition stop</b> <b>Example:</b> Device# <code>debug platform condition stop</code>	Stops conditional debugging (this will stop radioactive tracing).
<b>Step 6</b>	<b>request platform software trace archive</b> [last {number} days] [target {crashinfo:   flashinfo:}] <b>Example:</b> Device# <code>request platform software trace archive last 2 days</code>	(Optional) Displays historical logs of merged tracefiles on the system. Filter on any combination of number of days or location.
<b>Step 7</b>	<b>request platform software trace filter-binary</b> {wire   wireless} [context {mac-address}   level   module] <b>Example:</b> Device# <code>request platform software trace filter-binary wireless context bc16.6509.3314</code>	(Optional) Filters the modules to collate the information (wire or wireless) and then on the context of Mac address specified. These logs can be viewed off-line.  <b>Note</b> In Cisco IOS XE Denali 16.1.1, from all the keywords available, the only keyword supported is wireless. This collects files from processes (ios, wcm, fman_rp, fman_fp, fed).
<b>Step 8</b>	<b>show platform software trace</b> [filter-binary   level   message] <b>Example:</b> Device# <code>show platform software trace message</code>	(Optional) Displays logs merged from the latest tracefile. Filter on any combination of application condition, trace module name, and trace level.  <ul style="list-style-type: none"> <li>• <b>filter-binary</b> - Filter the modules to be collated</li> <li>• <b>level</b> - Show trace levels</li> <li>• <b>message</b> - Show trace message ring contents</li> </ul> <b>Note</b> On Box: <ul style="list-style-type: none"> <li>• Available from IOS console in addition to linux shell.</li> <li>• Generates a file with merged logs on the box.</li> <li>• Displays merged logs only from staging area</li> </ul>
<b>Step 9</b>	<b>clear platform condition all</b> <b>Example:</b> Device# <code>clear platform condition all</code>	Clears all conditions.



**What to do next**

**Note** The commands **request platform software trace filter-binary** and **show platform software trace filter-binary** work in a similar way. The only difference is:

- **request platform software trace filter-binary** - Sources the data from historical logs.
- **show platform software trace filter-binary** – Sources the data from the flash Temp directory.



**Note** The command **request platform software trace filter-binary wireless {mac-address}** generates 3 flash files:

- *collated\_log\_<.date..>*
- *mac\_log <.date..>*
- *mac\_database ..file*

Of these, *mac\_log <.date..>* is the most important file, as it gives the messages for the MAC we are debugging. The command **show platform software trace filter-binary** also generates the same flash files, and also prints the *mac\_log* on the screen.

## Radioactive Tracing for L2 Multicast

To identify a specific multicast receiver, specify the MAC address of the joiner or the receiver client, Group Multicast IP address and Snooping VLAN. Additionally, enable the trace level for the debug. The debug level will provide detailed traces and better visibility into the system.

```
debug platform condition feature multicast controlplane mac client MAC address ip Group IP  
address vlan id level debug level
```

## Recommended Workflow for Trace files

The Recommended Workflow for Trace files is listed below:

1. To request the tracelogs for a specific time period.  
EXAMPLE 1 day.  
Use the command:  

```
Device#request platform software trace archive last 1 day
```
2. The system generates a tar ball (.gz file) of the tracelogs in the location /flash:
3. Copy the file off the switch. By copying the file, the tracelogs can be used to work offline. For more details on copying files, see section below.

4. Delete the tracelog file (.gz) file from /flash: location. This will ensure enough space on the switch for other operations.

## Copying tracefiles off the box

An example of the tracefile is shown below:

```
Device# dir crashinfo:/tracelogs
Directory of crashinfo:/tracelogs/

50664 -rwx 760 Sep 22 2015 11:12:21 +00:00 plogd_F0-0.bin_0.gz
50603 -rwx 991 Sep 22 2015 11:12:08 +00:00 fed_pmanlog_F0-0.bin_0.9558.20150922111208.gz
50610 -rw- 11 Nov 2 2015 00:15:59 +00:00 timestamp
50611 -rwx 1443 Sep 22 2015 11:11:31 +00:00
auto_upgrade_client_sh_pmanlog_R0-.bin_0.3817.20150922111130.gz
50669 -rwx 589 Sep 30 2015 03:59:04 +00:00 cfgwr-8021_R0-0.bin_0.gz
50612 -rwx 1136 Sep 22 2015 11:11:46 +00:00 reflector_803_R0-0.bin_0.1312.20150922111116.gz
50794 -rwx 4239 Nov 2 2015 00:04:32 +00:00 IOSRP_R0-0.bin_0.14239.20151101234827.gz
50615 -rwx 131072 Nov 2 2015 00:19:59 +00:00 linux_iosd_image_pmanlog_R0-0.bin_0
--More--
```

The trace files can be copied using one of the various options shown below:

```
Device# copy crashinfo:/tracelogs ?
 crashinfo: Copy to crashinfo: file system
 flash: Copy to flash: file system
 ftp: Copy to ftp: file system
 http: Copy to http: file system
 https: Copy to https: file system
 null: Copy to null: file system
 nvram: Copy to nvram: file system
 rcp: Copy to rcp: file system
 running-config Update (merge with) current system configuration
 scp: Copy to scp: file system
 startup-config Copy to startup configuration
 syslog: Copy to syslog: file system
 system: Copy to system: file system
 tftp: Copy to tftp: file system
 tmpsys: Copy to tmpsys: file system
```

The general syntax for copying onto a TFTP server is as follows:

```
Device# copy source: tftp:
Device# copy crashinfo:/tracelogs/IOSRP_R0-0.bin_0.14239.20151101234827.gz tftp:
Address or name of remote host []? 2.2.2.2
Destination filename [IOSRP_R0-0.bin_0.14239.20151101234827.gz]?
```




---

**Note** It is important to clear the generated report or archive files off the switch in order to have flash space available for tracelog and other purposes.

---

## Configuration Examples for Conditional Debugging

The following is an output example of the *show platform condition* command.

```
Device# show platform condition
Conditional Debug Global State: Stop
Conditions Direction
-----|-----
MAC Address 0024.D7C7.0054 N/A
Feature Condition Type Value
-----|-----
Device#
```

The following is an output example of the *show debug* command.

```
Device# show debug
IOSXE Conditional Debug Configs:
Conditional Debug Global State: Start
Conditions Direction
-----|-----
MAC Address 0024.D7C7.0054 N/A
Feature Condition Type Value
-----|-----
Packet Infra debugs:
Ip Address Port
-----|-----
Device#
```

The following is a sample of the *debug platform condition stop* command.

```
Device# debug platform condition stop
Conditional Debug Global State: Stop
```

## Monitoring Conditional Debugging

The table shown below lists the various commands that can be used to monitor conditional debugging.

Command	Purpose
<b>show platform condition</b>	Displays the current conditions set.
<b>show debug</b>	Displays the current debug conditions set.
<b>show platform software trace filter-binary</b>	Displays logs merged from the latest tracefile.
<b>request platform software trace filter-binary</b>	Displays historical logs of merged tracefiles on the system.





## CHAPTER 152

# Troubleshooting the Software Configuration

This chapter describes how to identify and resolve software problems related to the Cisco IOS software on the switch. Depending on the nature of the problem, you can use the command-line interface (CLI), Device Manager, or Network Assistant to identify and solve problems.

Additional troubleshooting information, such as LED descriptions, is provided in the hardware installation guide.

- [Finding Feature Information, on page 2719](#)
- [Information About Troubleshooting the Software Configuration, on page 2719](#)
- [How to Troubleshoot the Software Configuration, on page 2728](#)
- [Verifying Troubleshooting of the Software Configuration, on page 2740](#)
- [Scenarios for Troubleshooting the Software Configuration, on page 2742](#)
- [Configuration Examples for Troubleshooting Software, on page 2744](#)
- [Additional References for Troubleshooting Software Configuration, on page 2746](#)
- [Feature History and Information for Troubleshooting Software Configuration, on page 2747](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Troubleshooting the Software Configuration

### Software Failure on a Switch

Switch software can be corrupted during an upgrade by downloading the incorrect file to the switch, and by deleting the image file. In all of these cases, the switch does not pass the power-on self-test (POST), and there is no connectivity.

**Related Topics**

[Recovering from a Software Failure](#), on page 2728

## Lost or Forgotten Password on a Device

The default configuration for the device allows an end user with physical access to the device to recover from a lost password by interrupting the boot process during power-on and by entering a new password. These recovery procedures require that you have physical access to the device.



---

**Note** On these devices, a system administrator can disable some of the functionality of this feature by allowing an end user to reset a password only by agreeing to return to the default configuration. If you are an end user trying to reset a password when password recovery has been disabled, a status message reminds you to return to the default configuration during the recovery process.

---



---

**Note** You cannot recover encryption password key, when Cisco WLC configuration is copied from one Cisco WLC to another (in case of an RMA).

---

**Related Topics**

[Recovering from a Lost or Forgotten Password](#), on page 2730

## Power over Ethernet Ports

A Power over Ethernet (PoE) switch port automatically supplies power to one of these connected devices if the switch detects that there is no power on the circuit:

- a Cisco pre-standard powered device (such as a Cisco IP Phone or a Cisco Aironet Access Point)
- an IEEE 802.3af-compliant powered device
- an IEEE 802.3at-compliant powered device

A powered device can receive redundant power when it is connected to a PoE switch port and to an AC power source. The device does not receive redundant power when it is only connected to the PoE port.

After the switch detects a powered device, the switch determines the device power requirements and then grants or denies power to the device. The switch can also detect the real-time power consumption of the device by monitoring and policing the power usage.

For more information, see the "Configuring PoE" chapter in the *Interface and Hardware Component Configuration Guide (Catalyst 3850 Switches)*.

**Related Topics**

[Scenarios to Troubleshoot Power over Ethernet \(PoE\)](#), on page 2742

## Disabled Port Caused by Power Loss

If a powered device (such as a Cisco IP Phone 7910) that is connected to a PoE Device port and powered by an AC power source loses power from the AC power source, the device might enter an error-disabled state.

To recover from an error-disabled state, enter the **shutdown** interface configuration command, and then enter the **no shutdown** interface command. You can also configure automatic recovery on the Device to recover from the error-disabled state.

On a Device, the **errdisable recovery cause loopback** and the **errdisable recovery interval seconds** global configuration commands automatically take the interface out of the error-disabled state after the specified period of time.

## Disabled Port Caused by False Link-Up

If a Cisco powered device is connected to a port and you configure the port by using the **power inline never** interface configuration command, a false link-up can occur, placing the port into an error-disabled state. To take the port out of the error-disabled state, enter the **shutdown** and the **no shutdown** interface configuration commands.

You should not connect a Cisco powered device to a port that has been configured with the **power inline never** command.

## Ping

The Device supports IP ping, which you can use to test connectivity to remote hosts. Ping sends an echo request packet to an address and waits for a reply. Ping returns one of these responses:

- Normal response—The normal response (*hostname is alive*) occurs in 1 to 10 seconds, depending on network traffic.
- Destination does not respond—If the host does not respond, a *no-answer* message is returned.
- Unknown host—If the host does not exist, an *unknown host* message is returned.
- Destination unreachable—If the default gateway cannot reach the specified network, a *destination-unreachable* message is returned.
- Network or host unreachable—If there is no entry in the route table for the host or network, a *network or host unreachable* message is returned.

### Related Topics

[Executing Ping](#), on page 2736

[Example: Pinging an IP Host](#), on page 2744

## Layer 2 Traceroute

The Layer 2 traceroute feature allows the switch to identify the physical path that a packet takes from a source device to a destination device. Layer 2 traceroute supports only unicast source and destination MAC addresses. Traceroute finds the path by using the MAC address tables of the Device in the path. When the Device detects a device in the path that does not support Layer 2 traceroute, the Device continues to send Layer 2 trace queries and lets them time out.

The Device can only identify the path from the source device to the destination device. It cannot identify the path that a packet takes from source host to the source device or from the destination device to the destination host.

## Layer 2 Traceroute Guidelines

- Cisco Discovery Protocol (CDP) must be enabled on all the devices in the network. For Layer 2 traceroute to function properly, do not disable CDP.  
If any devices in the physical path are transparent to CDP, the switch cannot identify the path through these devices.
- A Device is reachable from another Device when you can test connectivity by using the **ping** privileged EXEC command. All Device in the physical path must be reachable from each other.
- The maximum number of hops identified in the path is ten.
- You can enter the **traceroute mac** or the **traceroute mac ip** privileged EXEC command on a Device that is not in the physical path from the source device to the destination device. All Device in the path must be reachable from this switch.
- The **traceroute mac** command output shows the Layer 2 path only when the specified source and destination MAC addresses belong to the same VLAN. If you specify source and destination MAC addresses that belong to different VLANs, the Layer 2 path is not identified, and an error message appears.
- If you specify a multicast source or destination MAC address, the path is not identified, and an error message appears.
- If the source or destination MAC address belongs to multiple VLANs, you must specify the VLAN to which both the source and destination MAC addresses belong. If the VLAN is not specified, the path is not identified, and an error message appears.
- The **traceroute mac ip** command output shows the Layer 2 path when the specified source and destination IP addresses belong to the same subnet. When you specify the IP addresses, the Device uses the Address Resolution Protocol (ARP) to associate the IP addresses with the corresponding MAC addresses and the VLAN IDs.
  - If an ARP entry exists for the specified IP address, the Device uses the associated MAC address and identifies the physical path.
  - If an ARP entry does not exist, the Device sends an ARP query and tries to resolve the IP address. If the IP address is not resolved, the path is not identified, and an error message appears.
- When multiple devices are attached to one port through hubs (for example, multiple CDP neighbors are detected on a port), the Layer 2 traceroute feature is not supported. When more than one CDP neighbor is detected on a port, the Layer 2 path is not identified, and an error message appears.
- This feature is not supported in Token Ring VLANs.
- Layer 2 traceroute opens a listening socket on the User Datagram Protocol (UDP) port 2228 that can be accessed remotely with any IPv4 address, and does not require any authentication. This UDP socket allows to read VLAN information, links, presence of particular MAC addresses, and CDP neighbor information, from the device. This information can be used to eventually build a complete picture of the Layer 2 network topology.
- Layer 2 traceroute is enabled by default and can be disabled by running the **no l2 traceroute** command in global configuration mode. To re-enable Layer 2 traceroute, use the **l2 traceroute** command in global configuration mode.



## IP Traceroute

You can use IP traceroute to identify the path that packets take through the network on a hop-by-hop basis. The command output displays all network layer (Layer 3) devices, such as routers, that the traffic passes through on the way to the destination.

Your Device can participate as the source or destination of the **traceroute** privileged EXEC command and might or might not appear as a hop in the **traceroute** command output. If the Device is the destination of the traceroute, it is displayed as the final destination in the traceroute output. Intermediate Device do not show up in the traceroute output if they are only bridging the packet from one port to another within the same VLAN. However, if the intermediate Device is a multilayer Device that is routing a particular packet, this Device shows up as a hop in the traceroute output.

The **traceroute** privileged EXEC command uses the Time To Live (TTL) field in the IP header to cause routers and servers to generate specific return messages. Traceroute starts by sending a User Datagram Protocol (UDP) datagram to the destination host with the TTL field set to 1. If a router finds a TTL value of 1 or 0, it drops the datagram and sends an Internet Control Message Protocol (ICMP) time-to-live-exceeded message to the sender. Traceroute finds the address of the first hop by examining the source address field of the ICMP time-to-live-exceeded message.

To identify the next hop, traceroute sends a UDP packet with a TTL value of 2. The first router decrements the TTL field by 1 and sends the datagram to the next router. The second router sees a TTL value of 1, discards the datagram, and returns the time-to-live-exceeded message to the source. This process continues until the TTL is incremented to a value large enough for the datagram to reach the destination host (or until the maximum TTL is reached).

To learn when a datagram reaches its destination, traceroute sets the UDP destination port number in the datagram to a very large value that the destination host is unlikely to be using. When a host receives a datagram destined to itself containing a destination port number that is unused locally, it sends an ICMP *port-unreachable* error to the source. Because all errors except port-unreachable errors come from intermediate hops, the receipt of a port-unreachable error means that this message was sent by the destination port.

### Related Topics

[Executing IP Traceroute](#), on page 2738

[Example: Performing a Traceroute to an IP Host](#), on page 2745

## Time Domain Reflector Guidelines

You can use the Time Domain Reflector (TDR) feature to diagnose and resolve cabling problems. When running TDR, a local device sends a signal through a cable and compares the reflected signal to the initial signal.

TDR is supported on 10/100/1000 copper Ethernet ports and on Multigigabit Ethernet (100Mbps/1/2.5/5/10 Gbps) ports. It is not supported on SFP module ports.

TDR can detect these cabling problems:

- Open, broken, or cut twisted-pair wires—The wires are not connected to the wires from the remote device.
- Shorted twisted-pair wires—The wires are touching each other or the wires from the remote device. For example, a shorted twisted pair can occur if one wire of the twisted pair is soldered to the other wire.

If one of the twisted-pair wires is open, TDR can find the length at which the wire is open.



---

**Note** When using the feature with Multigigabit Ethernet ports, the cable length is displayed only when an open or short condition is detected.

---

Use TDR to diagnose and resolve cabling problems in these situations:

- Replacing a Device
- Setting up a wiring closet
- Troubleshooting a connection between two devices when a link cannot be established or when it is not operating properly

When you run TDR, the Device reports accurate information in these situations:

- The cable for the gigabit link is a solid-core cable.
- The open-ended cable is not terminated.

When you run TDR, the Device does not report accurate information in these situations:

- The cable for the gigabit link is a twisted-pair cable or is in series with a solid-core cable.
- The link is a 10-megabit or a 100-megabit link.
- The cable is a stranded cable.
- The link partner is a Cisco IP Phone.
- The link partner is not IEEE 802.3 compliant.

## Debug Commands



---

**Caution** Because debugging output is assigned high priority in the CPU process, it can render the system unusable. For this reason, use **debug** commands only to troubleshoot specific problems or during troubleshooting sessions with Cisco technical support staff. It is best to use **debug** commands during periods of lower network traffic and fewer users. Debugging during these periods decreases the likelihood that increased **debug** command processing overhead will affect system use.

---

All **debug** commands are entered in privileged EXEC mode, and most **debug** commands take no arguments.

### Related Topics

[Redirecting Debug and Error Message Output](#), on page 2738

[Example: Enabling All System Diagnostics](#), on page 2746

## System Report

System reports or crashinfo files save information that helps Cisco technical support representatives to debug problems that caused the Cisco IOS image to fail (crash). It is necessary to quickly and reliably collect critical

crash information with high fidelity and integrity. Further, it is necessary to collect this information and bundle it in a way that it can be associated or identified with a specific crash occurrence.

System reports are generated in these situations:

- In case of a switch failure—A system report is generated on the member that failed; reports are not generated on other members in the stack.
- In case of a switchover—System reports are generated only on high availability (HA) member switches. reports are not generated for non-HA members.

The system does not generate reports in case of a reload.

During a process crash, the following is collected locally from the switch:

1. Full process core
2. Tracelogs
3. IOS syslogs (not guaranteed in case of non-active crashes)
4. System process information
5. Bootup logs
6. Reload logs
7. Certain types of /proc information

This information is stored in separate files which are then archived and compressed into one bundle. This makes it convenient to get a crash snapshot in one place, and can be then moved off the box for analysis. This report is generated before the switch goes down to rommon/bootloader.

Except for the full core and tracelogs, everything else is a text file.

### Crashinfo Files

By default the system report file will be generated and saved into the /crashinfo directory. If it cannot be saved to the crashinfo partition for lack of space, then it will be saved to the /flash directory.

To display the files, enter the **dir crashinfo:** command. The following is sample output of a crashinfo directory:

```
Switch#dir crashinfo:
Directory of crashinfo:/
46553 drwx 1024 Jun 29 2015 14:52:09 +00:00 ap_crash
12 -rw- 0 Jan 1 1970 00:00:11 +00:00 koops.dat
11 -rw- 0 Mar 22 2013 07:50:30 +00:00 deleted_crash_files
13 -rwx 594269 Mar 22 2013 07:50:30 +00:00 crashinfo_platform_mgr_20130322-075017-UTC
14 -rw- 44 Sep 9 2015 09:28:47 +00:00 last_crashinfo
15 -rw- 355 Sep 9 2015 09:29:31 +00:00 last_systemreport_log
16 -rw- 105753 Mar 22 2013 07:50:47 +00:00 system-report_1_20130322-075017-UTC.gz
17 -rw- 39 Sep 9 2015 09:29:31 +00:00 last_systemreport
18 -rwx 585996 Mar 22 2013 08:01:58 +00:00 crashinfo_platform_mgr_20130322-080144-UTC
19 -rw- 105065 Mar 22 2013 08:02:15 +00:00 system-report_1_20130322-080144-UTC.gz
20 -rwx 3426209 Sep 9 2015 06:49:12 +00:00 crashinfo_iosd_20150909-064754-UTC
21 -rwx 9540376 Sep 9 2015 06:49:13 +00:00 fullcore_iosd_20150909-064754-UTC
22 -rw- 469476 Sep 9 2015 06:49:56 +00:00 system-report_1_20150909-064754-UTC.gz
23 -rwx 3425350 Sep 9 2015 09:28:47 +00:00 crashinfo_iosd_20150909-092728-UTC
24 -rwx 9535535 Sep 9 2015 09:28:47 +00:00 fullcore_iosd_20150909-092728-UTC
25 -rw- 459709 Sep 9 2015 09:29:28 +00:00 system-report_1_20150909-092728-UTC.gz
26 -rw- 0 Sep 22 2015 11:11:33 +00:00 tracelogs.J8C
```

```
50601 drwx 10240 Oct 28 2015 22:42:50 +00:00 tracelogs
248354816 bytes total (204800000 bytes free)
```

System reports are located in the crashinfo directory in the following format:

```
system-report_[switch number]_[date]-[timestamp]-UTC.gz
```

After a switch crashes, check for a system report file. The name of the most recently generated system report file is stored in the last\_systemreport file under the crashinfo directory. The system report and crashinfo files assist TAC while troubleshooting the issue.

The system report generated can be further copied using TFTP, HTTP and few other options.

```
Switch#copy crashinfo: ?
crashinfo:      Copy to crashinfo: file system
flash:          Copy to flash: file system
ftp:            Copy to ftp: file system
http:           Copy to http: file system
https:          Copy to https: file system
null:           Copy to null: file system
nvram:          Copy to nvram: file system
rcp:            Copy to rcp: file system
running-config Update (merge with) current system configuration
scp:            Copy to scp: file system
startup-config Copy to startup configuration
syslog:         Copy to syslog: file system
system:         Copy to system: file system
tftp:           Copy to tftp: file system
tmpsys:         Copy to tmpsys: file system
```

The general syntax for copying onto TFTP server is as follows:

```
Switch#copy crashinfo: tftp:
Source filename [system-report_1_20150909-092728-UTC.gz]?
Address or name of remote host []? 1.1.1.1
Destination filename [system-report_1_20150909-092728-UTC.gz]?
```

The tracelogs from all members in the stack can be collected by issuing a trace archive command. This command provides time period options. The command syntax is as follows:

```
Switch#request platform software trace archive ?
last      Archive trace files of last x days
target    Location and name for the archive file
```

The tracelogs stored in crashinfo: or flash: directory from within the last 3650 days can be collected.

```
Switch# request platform software trace archive last ?
<1-3650> Number of days (1-3650)
Switch#request platform software trace archive last 3650 days target ?
crashinfo: Archive file name and location
flash:      Archive file name and location
```



**Note** It is important to clear the system reports or trace archives from flash or crashinfo directory once they are copied out, in order to have space available for tracelogs and other purposes.

## Onboard Failure Logging on the Switch

You can use the onboard failure logging (OBFL) feature to collect information about the Device. The information includes uptime, temperature, and voltage information and helps Cisco technical support

representatives to troubleshoot Device problems. We recommend that you keep OBFL enabled and do not erase the data stored in the flash memory.

By default, OBFL is enabled. It collects information about the Device and small form-factor pluggable (SFP) modules. The Device stores this information in the flash memory:

- CLI commands—Record of the OBFL CLI commands that are entered on a standalone Device or a switch stack member.
- Environment data—Unique device identifier (UDI) information for a standalone Device or a switch stack member and for all the connected FRU devices: the product identification (PID), the version identification (VID), and the serial number.
- Message—Record of the hardware-related system messages generated by a standalone Device or a switch stack member.
- Power over Ethernet (PoE)—Record of the power consumption of PoE ports on a standalone Device or a switch stack member.
- Temperature—Temperature of a standalone Device or a switch stack member.
- Uptime data—Time when a standalone Device or a switch stack member starts, the reason the Device restarts, and the length of time the Device has been running since it last restarted.
- Voltage—System voltages of a standalone Device or a switch stack member.

You should manually set the system clock or configure it by using Network Time Protocol (NTP).

When the Device is running, you can retrieve the OBFL data by using the **show logging onboard** privileged EXEC commands. If the Device fails, contact your Cisco technical support representative to find out how to retrieve the data.

When an OBFL-enabled Device is restarted, there is a 10-minute delay before logging of new data begins.

### Related Topics

[Configuring OBFL](#), on page 2739

[Displaying OBFL Information](#), on page 2740

## Fan Failures

By default, the feature is disabled. When more than one of the fans fails in a field-replaceable unit (FRU) or in a power supply, the Device does not shut down, and this error message appears:

```
Multiple fan(FRU/PS) failure detected. System may get overheated. Change fan quickly.
```

The Device might overheat and shut down.

To enable the fan failures feature, enter the **system env fan-fail-action shut** privileged EXEC command. If more than one fan in the Device fails, the Device automatically shuts down, and this error message appears:

```
Faulty (FRU/PS) fans detected, shutting down system!
```

After the first fan shuts down, if the Device detects a second fan failure, the Device waits for 20 seconds before it shuts down.

To restart the Device, it must be power cycled.

## Possible Symptoms of High CPU Utilization

Excessive CPU utilization might result in these symptoms, but the symptoms might also result from other causes:




---

**Note** You may see increased system memory usage when Cisco Catalyst 4500E Supervisor Engine 8-E is used in wireless mode.

---

- Spanning tree topology changes
- EtherChannel links brought down due to loss of communication
- Failure to respond to management requests (ICMP ping, SNMP timeouts, slow Telnet or SSH sessions)
- UDLD flapping
- IP SLAs failures because of SLAs responses beyond an acceptable threshold
- DHCP or IEEE 802.1x failures if the switch does not forward or respond to requests

## How to Troubleshoot the Software Configuration

### Recovering from a Software Failure

#### Before you begin

This recovery procedure requires that you have physical access to the switch.

This procedure uses boot loader commands and TFTP to recover from a corrupted or incorrect image file.

#### Procedure

---

- Step 1** From your PC, download the software image file (*image.bin*) from Cisco.com.
- Step 2** Load the software image to your TFTP server.
- Step 3** Connect your PC to the switch Ethernet management port.
- Step 4** Unplug the switch power cord.
- Step 5** Press the **Mode** button, and at the same time, reconnect the power cord to the switch.
- Step 6** From the bootloader (ROMMON) prompt, ensure that you can ping your TFTP server.
  - a) Set the IP address **switch: set IP\_ADDRESS ip\_address subnet\_mask**

#### Example:

```
switch: set IP_ADDRESS 192.0.2.123/255.255.255.0
```



```

### Launching Linux Kernel (flags = 0x5)

Initiating Emergency Installation of bundle
tftp://192.0.2.47/cat3k/cat3k_caa-universalk9.SSA.03.12.02.EZP.150-12.02.EZP.150-12.02.EZP.bin

Downloading bundle
tftp://192.0.2.47/cat3k/cat3k_caa-universalk9.SSA.03.12.02.EZP.150-12.02.EZP.150-12.02.EZP.bin...
Validating bundle
tftp://192.0.2.47/cat3k/cat3k_caa-universalk9.SSA.03.12.02.EZP.150-12.02.EZP.150-12.02.EZP.bin...
Installing bundle
tftp://192.0.2.47/cat3k/cat3k_caa-universalk9.SSA.03.12.02.EZP.150-12.02.EZP.150-12.02.EZP.bin...
Verifying bundle
tftp://192.0.2.47/cat3k/cat3k_caa-universalk9.SSA.03.12.02.EZP.150-12.02.EZP.150-12.02.EZP.bin...
Package cat3k_caa-base..pkg is Digitally Signed
Package cat3k_caa-drivers.SPA.03.02.00.SE.pkg is Digitally Signed
Package cat3k_caa-infra.SPA.03.02.00.SE.pkg is Digitally Signed
Package cat3k_caa-iosd-universalk9.SPA.03.02.00.SE.pkg is Digitally Signed
Package cat3k_caa-platform.SPA.03.02.00.SE.pkg is Digitally Signed
Package cat3k_caa-wcm.SPA.03.02.00.SE.pkg is Digitally Signed
Preparing flash...
Syncing device...
Emergency Install successful... Rebooting
Restarting system.

Booting...(use DDR clock 667 MHz)Initializing and Testing RAM +++@@@#####...++@++@++@++@

```

---

### Related Topics

[Software Failure on a Switch](#), on page 2719

## Recovering from a Lost or Forgotten Password

The default configuration for the switch allows an end user with physical access to the switch to recover from a lost password by interrupting the boot process during power-on and by entering a new password. These recovery procedures require that you have physical access to the switch.




---

**Note** On these switches, a system administrator can disable some of the functionality of this feature by allowing an end user to reset a password only by agreeing to return to the default configuration. If you are an end user trying to reset a password when password recovery has been disabled, a status message shows this during the recovery process.

---

### Procedure

---

**Step 1** Connect a terminal or PC to the switch.



- Connect a terminal or a PC with terminal-emulation software to the switch console port.
- Connect a PC to the Ethernet management port.

- Step 2** Set the line speed on the emulation software to 9600 baud.
- Step 3** Power off the standalone switch or the entire switch stack.
- Step 4** Reconnect the power cord to the or the active switch. Within 15 seconds, press the **Mode** button while the System LED is still flashing green. Continue pressing the **Mode** button until a prompt is seen; then release the **Mode** button.

```
Switch:
Xmodem file system is available.
Base ethernet MAC Address: 20:37:06:4d:e9:80
Verifying bootloader digital signature.
```

The system has been interrupted prior to loading the operating system software, console will be reset to 9600 baud rate.

Proceed to the *Procedure with Password Recovery Enabled* section, and follow the steps.

- Step 5** After recovering the password, reload the switch or the active switch .

On a switch:

```
Switch> reload
Proceed with reload? [confirm] y
```

---

### Related Topics

[Lost or Forgotten Password on a Device](#), on page 2720

## Procedure with Password Recovery Enabled

If the password-recovery operation is enabled, this message appears:

### Procedure

---

- Step 1** Initialize the flash file system.
- ```
Switch: flash_init
```
- Step 2** Ignore the startup configuration with the following command:
- ```
Switch: SWITCH_IGNORE_STARTUP_CFG=1
```
- Step 3** Boot the switch with the *packages.conf* file from flash.

```
Switch: boot flash:packages.conf
```

**Step 4** Terminate the initial configuration dialog by answering **No**.

```
Would you like to enter the initial configuration dialog? [yes/no]: No
```

**Step 5** At the switch prompt, enter privileged EXEC mode.

```
Switch> enable  
Switch#
```

**Step 6** Copy the startup configuration to running configuration.

```
Switch# copy startup-config running-config Destination filename [running-config]?
```

Press Return in response to the confirmation prompts. The configuration file is now reloaded, and you can change the password.

**Step 7** Enter global configuration mode and change the **enable** password.

```
Switch# configure terminal  
Switch(config)#
```

**Step 8** Write the running configuration to the startup configuration file.

```
Switch(config)# copy running-config startup-config
```

**Step 9** Confirm that manual boot mode is enabled.

```
Switch# show boot  
  
BOOT variable = flash:packages.conf;  
Manual Boot = yes  
Enable Break = yes
```

**Step 10** Reload the device.

```
Switch# reload
```

**Step 11** Return the Bootloader parameters (previously changed in Steps 2 and 3) to their original values.

```
switch: SWITCH_IGNORE_STARTUP_CFG=0
```

**Step 12** Boot the device with the *packages.conf* file from flash.

```
Switch: boot flash:packages.conf
```

**Step 13** After the device boots up, disable manual boot on the device.

```
Switch(config)# no boot manual
```

---

## Procedure with Password Recovery Disabled

If the password-recovery mechanism is disabled, this message appears:

```
The password-recovery mechanism has been triggered, but
is currently disabled. Access to the boot loader prompt
through the password-recovery mechanism is disallowed at
this point. However, if you agree to let the system be
reset back to the default system configuration, access
to the boot loader prompt can still be allowed.
```

```
Would you like to reset the system back to the default configuration (y/n)?
```



---

**Caution**

Returning the Device to the default configuration results in the loss of all existing configurations. We recommend that you contact your system administrator to verify if there are backup Device and VLAN configuration files.

- If you enter **n** (no), the normal boot process continues as if the **Mode** button had not been pressed; you cannot access the boot loader prompt, and you cannot enter a new password. You see the message:

```
Press Enter to continue.....
```

- If you enter **y** (yes), the configuration file in flash memory and the VLAN database file are deleted. When the default configuration loads, you can reset the password.

---

### Procedure

**Step 1** Choose to continue with password recovery and delete the existing configuration:

```
Would you like to reset the system back to the default configuration (y/n)? y
```

**Step 2** Display the contents of flash memory:

```
Device: dir flash:
```

The Device file system appears.

```

Directory of flash:/
.
.
.i'
15494 drwx          4096   Jan 1 2000 00:20:20 +00:00 kirch
15508 -rw-   258065648   Sep 4 2013 14:19:03 +00:00
cat3k_caa-universalk9.SSA.03.12.02.EZP.150-12.02.EZP.150-12.02.EZP.bin
162196684

```

**Step 3** Boot up the system:

```
Device: boot
```

You are prompted to start the setup program. To continue with password recovery, enter **N** at the prompt:

```
Continue with the configuration dialog? [yes/no]: N
```

**Step 4** At the Device prompt, enter privileged EXEC mode:

```
Device> enable
```

**Step 5** Enter global configuration mode:

```
Device# configure terminal
```

**Step 6** Change the password:

```
Device(config)# enable secret password
```

The secret password can be from 1 to 25 alphanumeric characters, can start with a number, is case sensitive, and allows spaces but ignores leading spaces.

**Step 7** Return to privileged EXEC mode:

```
Device(config)# exit
Device#
```

**Note** Before continuing to Step 9, power on any connected stack members and wait until they have completely initialized.

**Step 8** Write the running configuration to the startup configuration file:

```
Device# copy running-config startup-config
```

The new password is now in the startup configuration.

**Step 9** You must now reconfigure the Device. If the system administrator has the backup Device and VLAN configuration files available, you should use those.

## Preventing Switch Stack Problems

To prevent switch stack problems, you should do the following:

- Make sure that the Device that you add to or remove from the switch stack are powered off. For all powering considerations in switch stacks, see the “Switch Installation” chapter in the hardware installation guide.
- Press the **Mode** button on a stack member until the Stack mode LED is on. The last two port LEDs on the Device should be green. Depending on the Device model, the last two ports are either 10/100/1000 ports or small form-factor pluggable (SFP) module. If one or both of the last two port LEDs are not green, the stack is not operating at full bandwidth.
- We recommend using only one CLI session when managing the switch stack. Be careful when using multiple CLI sessions to the active switch. Commands that you enter in one session are not displayed in the other sessions. Therefore, it is possible that you might not be able to identify the session from which you entered a command.
- Manually assigning stack member numbers according to the placement of the Device in the stack can make it easier to remotely troubleshoot the switch stack. However, you need to remember that the Device have manually assigned numbers if you add, remove, or rearrange Device later. Use the **switch current-stack-member-number renumber new-stack-member-number** global configuration command to manually assign a stack member number.

If you replace a stack member with an identical model, the new Device functions with the exact same configuration as the replaced Device. This is also assuming the new Device is using the same member number as the replaced Device.

Removing powered-on stack members causes the switch stack to divide (partition) into two or more switch stacks, each with the same configuration. If you want the switch stacks to remain separate, change the IP address or addresses of the newly created switch stacks. To recover from a partitioned switch stack, follow these steps:

1. Power off the newly created switch stacks.
2. Reconnect them to the original switch stack through their StackWise Plus ports.
3. Power on the Device.

For the commands that you can use to monitor the switch stack and its members, see the *Displaying Switch Stack Information* section.

## Preventing Autonegotiation Mismatches

The IEEE 802.3ab autonegotiation protocol manages the Device settings for speed (10 Mb/s, 100 Mb/s, and 1000 Mb/s, excluding SFP module ports) and duplex (half or full). There are situations when this protocol can incorrectly align these settings, reducing performance. A mismatch occurs under these circumstances:

- A manually set speed or duplex parameter is different from the manually set speed or duplex parameter on the connected port.
- A port is set to autonegotiate, and the connected port is set to full duplex with no autonegotiation.

To maximize Device performance and ensure a link, follow one of these guidelines when changing the settings for duplex and speed:

- Let both ports autonegotiate both speed and duplex.

- Manually set the speed and duplex parameters for the ports on both ends of the connection.



---

**Note** If a remote device does not autonegotiate, configure the duplex settings on the two ports to match. The speed parameter can adjust itself even if the connected port does not autonegotiate.

---

## Troubleshooting SFP Module Security and Identification

Cisco small form-factor pluggable (SFP) modules have a serial EEPROM that contains the module serial number, the vendor name and ID, a unique security code, and cyclic redundancy check (CRC). When an SFP module is inserted in the Device, the Device software reads the EEPROM to verify the serial number, vendor name and vendor ID, and recompute the security code and CRC. If the serial number, the vendor name or vendor ID, the security code, or CRC is invalid, the software generates a security error message and places the interface in an error-disabled state.



---

**Note** The security error message references the GBIC\_SECURITY facility. The Device supports SFP modules and does not support GBIC modules. Although the error message text refers to GBIC interfaces and modules, the security messages actually refer to the SFP modules and module interfaces.

---

If you are using a non-Cisco SFP module, remove the SFP module from the Device, and replace it with a Cisco module. After inserting a Cisco SFP module, use the **errdisable recovery cause gbic-invalid** global configuration command to verify the port status, and enter a time interval for recovering from the error-disabled state. After the elapsed interval, the Device brings the interface out of the error-disabled state and retries the operation. For more information about the **errdisable recovery** command, see the command reference for this release.

If the module is identified as a Cisco SFP module, but the system is unable to read vendor-data information to verify its accuracy, an SFP module error message is generated. In this case, you should remove and reinsert the SFP module. If it continues to fail, the SFP module might be defective.

## Monitoring SFP Module Status

You can check the physical or operational status of an SFP module by using the **show interfaces transceiver** privileged EXEC command. This command shows the operational status, such as the temperature and the current for an SFP module on a specific interface and the alarm status. You can also use the command to check the speed and the duplex settings on an SFP module. For more information, see the **show interfaces transceiver** command in the command reference for this release.

## Executing Ping

If you attempt to ping a host in a different IP subnetwork, you must define a static route to the network or have IP routing configured to route between those subnets.

IP routing is disabled by default on all Device.



**Note** Though other protocol keywords are available with the **ping** command, they are not supported in this release.

Use this command to ping another device on the network from the Device:

Command	Purpose
<b>ping ip</b> <i>host</i>   <i>address</i>  Device# ping 172.20.52.3	Pings a remote host through IP or by supplying the hostname or network address.

#### Related Topics

[Ping](#), on page 2721

[Example: Pinging an IP Host](#), on page 2744

## Monitoring Temperature

The Device monitors the temperature conditions and uses the temperature information to control the fans.

Use the **show env temperature status** privileged EXEC command to display the temperature value, state, and thresholds. The temperature value is the temperature in the Device (not the external temperature). You can configure only the yellow threshold level (in Celsius) by using the **system env temperature threshold yellow** *value* global configuration command to set the difference between the yellow and red thresholds. You cannot configure the green or red thresholds. For more information, see the command reference for this release.

## Monitoring the Physical Path

You can monitor the physical path that a packet takes from a source device to a destination device by using one of these privileged EXEC commands:

**Table 217: Monitoring the Physical Path**

Command	Purpose
<b>tracetroute mac</b> [ <b>interface</b> <i>interface-id</i> ] { <i>source-mac-address</i> } [ <b>interface</b> <i>interface-id</i> ] { <i>destination-mac-address</i> } [ <b>vlan</b> <i>vlan-id</i> ] [ <b>detail</b> ]	Displays the Layer 2 path taken by the packets from the specified source MAC address to the specified destination MAC address.
<b>tracetroute mac ip</b> { <i>source-ip-address</i>   <i>source-hostname</i> } { <i>destination-ip-address</i>   <i>destination-hostname</i> } [ <b>detail</b> ]	Displays the Layer 2 path taken by the packets from the specified source IP address or hostname to the specified destination IP address or hostname.

## Executing IP Traceroute



**Note** Though other protocol keywords are available with the **traceroute** privileged EXEC command, they are not supported in this release.

Command	Purpose
<b>traceroute ip host</b> Device# traceroute ip 192.51.100.1	Traces the path that packets take through the network.

### Related Topics

[IP Traceroute](#), on page 2723

[Example: Performing a Traceroute to an IP Host](#), on page 2745

## Running TDR and Displaying the Results

To run TDR, enter the **test cable-diagnostics tdr interface interface-id** privileged EXEC command.

To display the results, enter the **show cable-diagnostics tdr interface interface-id** privileged EXEC command.

## Redirecting Debug and Error Message Output

By default, the network server sends the output from **debug** commands and system error messages to the console. If you use this default, you can use a virtual terminal connection to monitor debug output instead of connecting to the console port or the Ethernet management port.

Possible destinations include the console, virtual terminals, internal buffer, and UNIX hosts running a syslog server. The syslog format is compatible with 4.3 Berkeley Standard Distribution (BSD) UNIX and its derivatives.



**Note** Be aware that the debugging destination you use affects system overhead. When you log messages to the console, very high overhead occurs. When you log messages to a virtual terminal, less overhead occurs. Logging messages to a syslog server produces even less, and logging to an internal buffer produces the least overhead of any method.

For more information about system message logging, see *Configuring System Message Logging*.

### Related Topics

[Debug Commands](#), on page 2724

## Using the show platform forward Command

The output from the **show platform forward** privileged EXEC command provides some useful information about the forwarding results if a packet entering an interface is sent through the system. Depending upon the



parameters entered about the packet, the output provides lookup table results and port maps used to calculate forwarding destinations, bitmaps, and egress information.

Most of the information in the output from the command is useful mainly for technical support personnel, who have access to detailed information about the Device application-specific integrated circuits (ASICs). However, packet forwarding information can also be helpful in troubleshooting.

## Using the show debug command

The **show debug** command is entered in privileged EXEC mode. This command displays all debug options available on the switch.

To view all conditional debug options run the command **show debug condition**. The commands can be listed by selecting either a condition identifier <1-1000> or *all* conditions.

To disable debugging, use the **no debug all** command.



### Caution

Because debugging output is assigned high priority in the CPU process, it can render the system unusable. For this reason, use **debug** commands only to troubleshoot specific problems or during troubleshooting sessions with Cisco technical support staff. Moreover, it is best to use **debug** commands during periods of lower network traffic and fewer users. Debugging during these periods decreases the likelihood that increased **debug** command processing overhead will affect system use.

For more information, see *Cisco IOS Configuration Fundamentals Command Reference, Cisco IOS XE Release 16.1 (Catalyst 3850 Switches)*.

## Configuring OBFL



### Caution

We recommend that you do not disable OBFL and that you do not remove the data stored in the flash memory.

- To enable OBFL, use the **hw-switch switch [switch-number] logging onboard [message level level]** global configuration command. On switches, the range for *switch-number* is from 1 to 9. Use the **message level level** parameter to specify the severity of the hardware-related messages that the switch generates and stores in the flash memory.
- To copy the OBFL data to the local network or a specific file system, use the **copy onboard switch switch-number url url-destination** privileged EXEC command.
- To disable OBFL, use the **no hw-switch switch [switch-number] logging onboard [message level]** global configuration command.
- To clear all the OBFL data in the flash memory except for the uptime and CLI command information, use the **clear onboard switch switch-number** privileged EXEC command.
- In a switch stack, you can enable OBFL on a standalone switch or on all stack members by using the **hw-switch switch [switch-number] logging onboard [message level level]** global configuration command.
- You can enable or disable OBFL on a member switch from the active switch.

For more information about the commands in this section, see the command reference for this release.

**Related Topics**

[Onboard Failure Logging on the Switch](#), on page 2726

[Displaying OBFL Information](#), on page 2740

# Verifying Troubleshooting of the Software Configuration

## Displaying OBFL Information

*Table 218: Commands for Displaying OBFL Information*

Command	Purpose
<b>show onboard switch <i>switch-number</i> clilog</b> Device# show onboard switch 1 clilog	Displays the OBFL CLI commands that were entered on a standalone switch or the specified stack members.
<b>show onboard switch <i>switch-number</i> environment</b> Device# show onboard switch 1 environment	Displays the UDI information for a standalone switch or the specified stack members and for all the connected FRU devices: the PID, the VID, and the serial number.
<b>show onboard switch <i>switch-number</i> message</b> Device# show onboard switch 1 message	Displays the hardware-related messages generated by a standalone switch or the specified stack members.
<b>show onboard switch <i>switch-number</i> counter</b> Device# show onboard switch 1 counter	Displays the counter information on a standalone switch or the specified stack members.
<b>show onboard switch <i>switch-number</i> temperature</b> Device# show onboard switch 1 temperature	Displays the temperature of a standalone switch or the specified switch stack members.
<b>show onboard switch <i>switch-number</i> uptime</b> Device# show onboard switch 1 uptime	Displays the time when a standalone switch or the specified stack members start, the reason the standalone switch or specified stack members restart, and the length of time that the standalone switch or specified stack members have been running since they last restarted.
<b>show onboard switch <i>switch-number</i> voltage</b> Device# show onboard switch 1 voltage	Displays the system voltages of a standalone switch or the specified stack members.
<b>show onboard switch <i>switch-number</i> status</b> Device# show onboard switch 1 status	Displays the status of a standalone switch or the specified stack members.

**Related Topics**

[Onboard Failure Logging on the Switch](#), on page 2726

[Configuring OBFL](#), on page 2739

**Example: Verifying the Problem and Cause for High CPU Utilization**

To determine if high CPU utilization is a problem, enter the **show processes cpu sorted** privileged EXEC command. Note the underlined information in the first line of the output example.

```
Device# show processes cpu sorted
CPU utilization for five seconds: 8%/0%; one minute: 7%; five minutes: 8%
PID Runtime(ms) Invoked uSecs 5Sec 1Min 5Min TTY Process
309 42289103 752750 56180 1.75% 1.20% 1.22% 0 RIP Timers
140 8820183 4942081 1784 0.63% 0.37% 0.30% 0 HRPC qos request
100 3427318 16150534 212 0.47% 0.14% 0.11% 0 HRPC pm-counters
192 3093252 14081112 219 0.31% 0.14% 0.11% 0 Spanning Tree
143 8 37 216 0.15% 0.01% 0.00% 0 Exec
...
<output truncated>
```

This example shows normal CPU utilization. The output shows that utilization for the last 5 seconds is 8%/0%, which has this meaning:

- The total CPU utilization is 8 percent, including both time running Cisco IOS processes and time spent handling interrupts.
- The time spent handling interrupts is zero percent.

**Table 219: Troubleshooting CPU Utilization Problems**

Type of Problem	Cause	Corrective Action
Interrupt percentage value is almost as high as total CPU utilization value.	The CPU is receiving too many packets from the network.	Determine the source of the network packet. Stop the flow, or change the switch configuration. See the section on “Analyzing Network Traffic.”
Total CPU utilization is greater than 50% with minimal time spent on interrupts.	One or more Cisco IOS process is consuming too much CPU time. This is usually triggered by an event that activated the process.	Identify the unusual event, and troubleshoot the root cause. See the section on “Debugging Active Processes.”

# Scenarios for Troubleshooting the Software Configuration

## Scenarios to Troubleshoot Power over Ethernet (PoE)

Table 220: Power over Ethernet Troubleshooting Scenarios

Symptom or Problem	Possible Cause and Solution
<p>Only one port does not have PoE.</p> <p>Trouble is on only one switch port.</p> <p>PoE and non-PoE devices do not work on this port, but do on other ports.</p>	<p>Verify that the powered device works on another PoE port.</p> <p>Use the <b>show run</b>, or <b>show interface status</b> user EXEC commands to verify that the port is not shut down or error-disabled.</p> <p><b>Note</b> Most switches turn off port power when the port is shut down, even though the IEEE specifications make this optional.</p> <p>Verify that <b>power inline never</b> is not configured on that interface or port.</p> <p>Verify that the Ethernet cable from the powered device to the switch port is good: Connect a known good non-PoE Ethernet device to the Ethernet cable, and make sure that the powered device establishes a link and exchanges traffic with another host.</p> <p><b>Note</b> Cisco powered device works only with straight cable and not with crossover one.</p> <p>Verify that the total cable length from the switch front panel to the powered device is not more than 100 meters.</p> <p>Disconnect the Ethernet cable from the switch port. Use a short Ethernet cable to connect a known good Ethernet device directly to this port on the switch front panel (not on a patch panel). Verify that it can establish an Ethernet link and exchange traffic with another host, or ping the port VLAN SVI. Next, connect a powered device to this port, and verify that it powers on.</p> <p>If a powered device does not power on when connected with a patch cord to the switch port, compare the total number of connected powered devices to the switch power budget (available PoE). Use the <b>show inline power</b> command to verify the amount of available power.</p>

Symptom or Problem	Possible Cause and Solution
<p>No PoE on all ports or a group of ports. Trouble is on all switch ports. Nonpowered Ethernet devices cannot establish an Ethernet link on any port, and PoE devices do not power on.</p>	<p>If there is a continuous, intermittent, or reoccurring alarm related to power, replace the power supply if possible it is a field-replaceable unit. Otherwise, replace the switch.</p> <p>If the problem is on a consecutive group of ports but not all ports, the power supply is probably not defective, and the problem could be related to PoE regulators in the switch.</p> <p>Use the <b>show log</b> privileged EXEC command to review alarms or system messages that previously reported PoE conditions or status changes.</p> <p>If there are no alarms, use the <b>show interface status</b> command to verify that the ports are not shut down or error-disabled. If ports are error-disabled, use the <b>shut</b> and <b>no shut</b> interface configuration commands to reenable the ports.</p> <p>Use the <b>show env power</b> and <b>show power inline</b> privileged EXEC commands to review the PoE status and power budget (available PoE).</p> <p>Review the running configuration to verify that <b>power inline never</b> is not configured on the ports.</p> <p>Connect a nonpowered Ethernet device directly to a switch port. Use only a short patch cord. Do not use the existing distribution cables. Enter the <b>shut</b> and <b>no shut</b> interface configuration commands, and verify that an Ethernet link is established. If this connection is good, use a short patch cord to connect a powered device to this port and verify that it powers on. If the device powers on, verify that all intermediate patch panels are correctly connected.</p> <p>Disconnect all but one of the Ethernet cables from switch ports. Using a short patch cord, connect a powered device to only one PoE port. Verify the powered device does not require more power than can be delivered by the switch port.</p> <p>Use the <b>show power inline</b> privileged EXEC command to verify that the powered device can receive power when the port is not shut down. Alternatively, watch the powered device to verify that it powers on.</p> <p>If a powered device can power on when only one powered device is connected to the switch, enter the <b>shut</b> and <b>no shut</b> interface configuration commands on the remaining ports, and then reconnect the Ethernet cables one at a time to the switch PoE ports. Use the <b>show interface status</b> and <b>show power inline</b> privileged EXEC commands to monitor inline power statistics and port status.</p> <p>If there is still no PoE at any port, a fuse might be open in the PoE section of the power supply. This normally produces an alarm. Check the log again for alarms reported earlier by system messages.</p>

Symptom or Problem	Possible Cause and Solution
<p>Cisco pre-standard powered device disconnects or resets.</p> <p>After working normally, a Cisco phone intermittently reloads or disconnects from PoE.</p>	<p>Verify all electrical connections from the switch to the powered device. Any unreliable connection results in power interruptions and irregular powered device functioning such as erratic powered device disconnects and reloads.</p> <p>Verify that the cable length is not more than 100 meters from the switch port to the powered device.</p> <p>Notice what changes in the electrical environment at the switch location or what happens at the powered device when the disconnect occurs.</p> <p>Notice whether any error messages appear at the same time a disconnect occurs. Use the <b>show log</b> privileged EXEC command to review error messages.</p> <p>Verify that an IP phone is not losing access to the Call Manager immediately before the reload occurs. (It might be a network problem and not a PoE problem.)</p> <p>Replace the powered device with a non-PoE device, and verify that the device works correctly. If a non-PoE device has link problems or a high error rate, the problem might be an unreliable cable connection between the switch port and the powered device.</p>
<p>IEEE 802.3af-compliant or IEEE 802.3at-compliant powered devices do not work on Cisco PoE switch.</p> <p>A non-Cisco powered device is connected to a Cisco PoE switch, but never powers on or powers on and then quickly powers off. Non-PoE devices work normally.</p>	<p>Use the <b>show power inline</b> command to verify that the switch power budget (available PoE) is not depleted before or after the powered device is connected. Verify that sufficient power is available for the powered device type before you connect it.</p> <p>Use the <b>show interface status</b> command to verify that the switch detects the connected powered device.</p> <p>Use the <b>show log</b> command to review system messages that reported an overcurrent condition on the port. Identify the symptom precisely: Does the powered device initially power on, but then disconnect? If so, the problem might be an initial surge-in (or <i>inrush</i>) current that exceeds a current-limit threshold for the port.</p>

**Related Topics**

[Power over Ethernet Ports](#), on page 2720

## Configuration Examples for Troubleshooting Software

### Example: Pinging an IP Host

This example shows how to ping an IP host:

```
Device# ping 172.20.52.3
```

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echoes to 172.20.52.3, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
Device#
```

**Table 221: Ping Output Display Characters**

Character	Description
!	Each exclamation point means receipt of a reply.
.	Each period means the network server timed out while waiting for a reply.
U	A destination unreachable error PDU was received.
C	A congestion experienced packet was received.
I	User interrupted test.
?	Unknown packet type.
&	Packet lifetime exceeded.

To end a ping session, enter the escape sequence (**Ctrl-^ X** by default). Simultaneously press and release the **Ctrl**, **Shift**, and **6** keys and then press the **X** key.

#### Related Topics

[Ping](#), on page 2721

[Executing Ping](#), on page 2736

## Example: Performing a Traceroute to an IP Host

This example shows how to perform a **traceroute** to an IP host:

```
Device# traceroute ip 192.0.2.10

Type escape sequence to abort.
Tracing the route to 192.0.2.10

 1 192.0.2.1 0 msec 0 msec 4 msec
 2 192.0.2.203 12 msec 8 msec 0 msec
 3 192.0.2.100 4 msec 0 msec 0 msec
 4 192.0.2.10 0 msec 4 msec 0 msec
```

The display shows the hop count, the IP address of the router, and the round-trip time in milliseconds for each of the three probes that are sent.

**Table 222: Traceroute Output Display Characters**

Character	Description
*	The probe timed out.
?	Unknown packet type.

Character	Description
A	Administratively unreachable. Usually, this output means that an access list is blocking traffic.
H	Host unreachable.
N	Network unreachable.
P	Protocol unreachable.
Q	Source quench.
U	Port unreachable.

To end a trace in progress, enter the escape sequence (**Ctrl-^ X** by default). Simultaneously press and release the **Ctrl**, **Shift**, and **6** keys and then press the **X** key.

#### Related Topics

[IP Traceroute](#), on page 2723

[Executing IP Traceroute](#), on page 2738

## Example: Enabling All System Diagnostics



#### Caution

Because debugging output takes priority over other network traffic, and because the **debug all** privileged EXEC command generates more output than any other **debug** command, it can severely diminish switch performance or even render it unusable. In virtually all cases, it is best to use more specific **debug** commands.

This command disables all-system diagnostics:

```
Device# debug all
```

The **no debug all** privileged EXEC command disables all diagnostic output. Using the **no debug all** command is a convenient way to ensure that you have not accidentally left any **debug** commands enabled.

#### Related Topics

[Debug Commands](#), on page 2724

## Additional References for Troubleshooting Software Configuration

#### Related Documents

Related Topic	Document Title
System management commands	<i>System Management Command Reference (Catalyst 3850 Switches)</i>



Related Topic	Document Title
Platform-independent command reference	<i>Configuration Fundamentals Command Reference, Cisco IOS XE Release 3S (Catalyst 3850 Switches)</i>
Platform_independent configuration information	<i>Configuration Fundamentals Configuration Guide, Cisco IOS XE Release 3S (Catalyst 3850 Switches)</i>

### Standards and RFCs

Standard/RFC	Title
None	—

### MIBs

MIB	MIBs Link
All supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for Troubleshooting Software Configuration

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.

**Related Topics**

[Finding Feature Information](#), on page 133



## PART **XX**

# VideoStream

- [VideoStream, on page 2751](#)





## CHAPTER 153

# VideoStream

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- [Finding Feature Information, on page 2751](#)
- [Information about VideoStream, on page 2751](#)
- [Prerequisites for VideoStream, on page 2751](#)
- [Restrictions for Configuring VideoStream, on page 2752](#)
- [How to Configure VideoStream, on page 2752](#)
- [Monitoring Media Streams, on page 2756](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information about VideoStream

The IEEE 802.11 wireless multicast delivery mechanism does not provide a reliable way to acknowledge lost or corrupted packets. The multicast frame packets are sent at a predetermined rate irrespective of the wireless client optimal data rate. As a result, if any multicast packet is lost in the air, it is not sent again which may cause an IP multicast stream unviewable. Also if the packets are delivered faster, the packets get congested.

The VideoStream feature makes the delivery of the IP multicast stream reliable over air, by converting the multicast frame to a unicast frame over the air. Each VideoStream client acknowledges receiving a video IP multicast stream.

## Prerequisites for VideoStream

- Make sure that the Multicast feature is enabled. We recommend that you configure IP multicast on the controller in multicast-multicast mode.

- Check for the IP address on the client machine. The machine should have an IP address from the respective VLAN.
- Verify that the access points have joined the controllers.

## Restrictions for Configuring VideoStream

IGMP snooping is required to switch ON for this MC2UC feature to be functional.

## How to Configure VideoStream

### Configuring Multicast-Direct Globally for Media Stream

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wireless multicast</b>	Enables multicast for wireless forwarding.
<b>Step 3</b>	<b>ip igmp snooping</b>	Enables IGMP snooping on a per-VLAN basis. If the global setting is disabled, then all the VLANs are treated as disabled, whether they are enabled or not.
<b>Step 4</b>	<b>ip igmp snooping querier</b>	Configures a snooping querier on an interface when there is no multicast router in the VLAN to generate queries.
<b>Step 5</b>	<b>wireless media-stream multicast-direct</b>  <b>Example:</b> (config)# <code>wireless media-stream multicast-direct</code>	Configures the global multicast-direct on the controller.
<b>Step 6</b>	<b>wireless media-stream message</b>  <b>Example:</b> (config)# <code>wireless media-stream message ?</code> Email Configure Session Announcement Email Notes Configure Session Announcement notes URL Configure Session Announcement URL	Configures various message-configuration parameters such as phone, URL, email, and notes. That is, when a media stream is refused (due to bandwidth constraints), a message can be sent to the corresponding user. These parameters configure the messages that are to be sent to the IT support email address, notes (message be displayed explaining why the stream was refused), URL to which the user can

	Command or Action	Purpose
	<pre> phone Configure Session Announcement Phone number &lt;cr&gt; </pre>	be redirected, and the phone number that the user can call about the refused stream.
<b>Step 7</b>	<p><b>wireless media-stream group name startIp endIp</b></p> <p><b>Example:</b></p> <pre> (config)#<b>wireless media-stream group grp1 231.1.1.1 239.1.1.3</b> (config-media-stream)#?    avg-packet-size  Configures average packet size   default          Set a command to its defaults   exit             Exit sub-mode   max-bandwidth    Configures maximum Expected Stream Bandwidth in Kbps   no              Negate a command or set its defaults   policy          Configure media stream admission policy   qos             Configure Over the AIR QoS class, '&lt;video&gt;' ONLY  &lt;cr&gt; </pre>	Configures each media stream and its parameters such as expected multicast destination addresses, stream bandwidth consumption, and stream-priority parameters.
<b>Step 8</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre> Device(config)# <b>end</b> </pre>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring Media Stream for 802.11 Bands

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre> Device# <b>configure terminal</b> </pre>	Enters global configuration mode.
<b>Step 2</b>	<p><b>ap dot11 {24ghz   5ghz} media-stream multicast-direct</b></p> <p><b>Example:</b></p> <pre> Device(config)#<b>ap dot11 24ghz media-stream multicast-direct</b> </pre>	Configures whether media stream (mc2uc) is allowed for the 802.11 band.
<b>Step 3</b>	<p><b>ap dot11 {24ghz   5ghz} media-stream video-redirect</b></p> <p><b>Example:</b></p>	Configures the redirection of unicast video traffic to the best-effort queue.

	Command or Action	Purpose
	Device (config) # <b>ap dot11 24ghz media-stream video-redirect</b>	
<b>Step 4</b>	<b>ap dot11 {24ghz   5ghz} media-stream multicast-direct admission-besteffort</b>  <b>Example:</b> Device (config) # <b>ap dot11 24ghz media-stream multicast-direct admission-besteffort</b>	Configures the media stream to be sent through the best-effort queue if that media stream cannot be prioritized due to bandwidth-availability limitations. Run the <b>no</b> form of the command to drop the stream, if the media stream cannot be prioritized due to bandwidth-availability limitations.
<b>Step 5</b>	<b>ap dot11 {24ghz   5ghz} media-stream multicast-direct client-maximum [value]</b>  <b>Example:</b> Device (config) # <b>ap dot11 24ghz media-stream multicast-direct client-max 15</b>	Configures the maximum number of allowed media streams per individual client. The maximum is 15 and the default is 0. The value of 0 denotes unlimited streams.
<b>Step 6</b>	<b>ap dot11 {24ghz   5ghz} media-stream multicast-direct radio-maximum [value]</b>	Configures maximum number of radio streams. The valid range is from 1 to 20. Default is 0. The value of 0 denotes unlimited streams.
<b>Step 7</b>	<b>ap dot11 {24ghz   5ghz} cac multimedia max-bandwidth [bandwidth]</b>  <b>Example:</b> Device (config) # <b>ap dot11 24ghz cac multimedia max-bandwidth 60</b>	Configures maximum media (voice + video) bandwidth, in percent. The range is between 5-85%.
<b>Step 8</b>	<b>ap dot11 {24ghz   5ghz} cac media-stream multicast-direct min_client_rate [dot11_rate]</b>  <b>Example:</b> Device (config) # <b>ap dot11 24ghz cac media-stream multicast-direct min_client_rate</b>	Configures the minimum PHY rate needed for a client to send a media stream as unicast. Clients communicating below this rate will not receive the media stream as a unicast flow. Typically, this PHY rate is equal to or higher than the rate at which multicast frames are sent.
<b>Step 9</b>	<b>ap dot11 5ghz cac media-stream</b>  <b>Example:</b> Device (config) # <b>ap dot11 5ghz cac media-stream</b>	Configures Call Admission Control (CAC) parameters for media stream access category.
<b>Step 10</b>	<b>ap dot11 5ghz cac multimedia</b>	Device (config) # <b>ap dot11 5ghz cac multimedia</b>  Configures CAC parameters for media access category: used for voice and video.
<b>Step 11</b>	<b>ap dot11 5ghz cac video</b>	Device (config) # <b>ap dot11 5ghz cac video</b>  Configures CAC parameters for video access category: used for voice signaling.
<b>Step 12</b>	<b>ap dot11 5ghz cac voice</b>	Device (config) # <b>ap dot11 5ghz cac voice</b>



	Command or Action	Purpose
		Configures CAC parameters for voice access category.
<b>Step 13</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring a WLAN to Stream Video (GUI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan wlan_name</b> <b>Example:</b> (config)# <b>wlan wlan50</b>	Enters WLAN configuration mode.
<b>Step 3</b>	<b>shutdown</b> <b>Example:</b> (config-wlan)# <b>shutdown</b>	Disables the WLAN for configuring its parameters.
<b>Step 4</b>	<b>media-stream multicast-direct</b> <b>Example:</b> (config)# <b>media-stream multicast-direct</b>	Configures the multicast-direct on media stream for the WLAN.
<b>Step 5</b>	<b>no shutdown</b> <b>Example:</b> (config-wlan)# <b>no shutdown</b>	Enables the WLAN.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Deleting a Media Stream

### Before you begin

The media stream should be enabled and configured for it to be deleted.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>no wireless media-stream group</b> <i>media_stream_name</i> <b>Example:</b> Device(config)# <code>no wireless media-stream grp1</code>	Deletes the media stream that bears the name mentioned in the command.
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Monitoring Media Streams

*Table 223: Commands for monitoring media streams*

<b>Commands</b>	<b>Description</b>
<code>show wireless media-stream client detail group name</code>	Displays media stream client details of the particular group.
<code>show wireless media-stream client summary</code>	Displays the media stream information of all the clients.
<code>show wireless media-stream group detail group name</code>	Displays the media stream configuration details of the particular group.
<code>show wireless media-stream group summary</code>	Displays the media stream configuration details of all the groups.
<code>show wireless media-stream message details</code>	Displays the session announcement message details.
<code>show wireless multicast</code>	Displays the multicast-direct configuration state.
<code>show ap dot11 24ghz   5ghz media-stream rrc</code>	Displays 802.11 media Resource-Reservation-Control configurations.



## PART **XXI**

### **VLAN**

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- [VLANs, on page 2783](#)
- [VLAN Groups, on page 2801](#)
- [Configuring VLAN Trunks, on page 2807](#)
- [Configuring Voice VLANs, on page 2827](#)
- [Configuring Private VLANs, on page 2837](#)





## CHAPTER 154

# Configuring VTP

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- [Prerequisites for VTP, on page 2759](#)
- [Restrictions for VTP, on page 2760](#)
- [Information About VTP, on page 2760](#)
- [How to Configure VTP, on page 2769](#)
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- [Configuration Examples for VTP, on page 2780](#)
- [Where to Go Next, on page 2780](#)
- [Additional References, on page 2780](#)
- [Feature History and Information for VTP, on page 2781](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for VTP

Before you create VLANs, you must decide whether to use the VLAN Trunking Protocol (VTP) in your network. Using VTP, you can make configuration changes centrally on one or more devices and have those changes automatically communicated to all the other devices in the network. Without VTP, you cannot send information about VLANs to other devices.

VTP is designed to work in an environment where updates are made on a single device and are sent through VTP to other devices in the domain. It does not work well in a situation where multiple updates to the VLAN database occur simultaneously on devices in the same domain, which would result in an inconsistency in the VLAN database.

The device supports a total of 4094 VLANs. However, the number of configured features affects the usage of the device hardware. If the device is notified by VTP of a new VLAN and the device is already using the maximum available hardware resources, it sends a message that there are not enough hardware resources available and shuts down the VLAN. The output of the **show vlan** user EXEC command shows the VLAN in a suspended state.

You can enable or disable VTP per port by entering the **[no] vtp** interface configuration command. When you disable VTP on trunking ports, all VTP instances for that port are disabled. You cannot set VTP to *off* for the MST database and *on* for the VLAN database on the same port.

When you globally set VTP mode to off, it applies to all the trunking ports in the system. However, you can specify on or off on a per-VTP instance basis. For example, you can configure the device as a VTP server for the VLAN database but with VTP *off* for the MST database.

Because trunk ports send and receive VTP advertisements, you must ensure that at least one trunk port is configured on the device or device stack and that this trunk port is connected to the trunk port of another device. Otherwise, the device cannot receive any VTP advertisements.

#### Related Topics

[VTP Advertisements](#), on page 2763

[Adding a VTP Client to a VTP Domain \(CLI\)](#), on page 2777

[VTP Domain](#), on page 2761

[VTP Modes](#), on page 2762

## Restrictions for VTP

The following are restrictions for a VTP:

- You cannot have a device stack containing a mix of Catalyst 3850 and Catalyst 3650 switches.



#### Caution

Before adding a VTP client device to a VTP domain, always verify that its VTP configuration revision number is lower than the configuration revision number of the other devices in the VTP domain. Devices in a VTP domain always use the VLAN configuration of the device with the highest VTP configuration revision number. If you add a device that has a revision number higher than the revision number in the VTP domain, it can erase all VLAN information from the VTP server and VTP domain.

## Information About VTP

### VTP

VTP is a Layer 2 messaging protocol that maintains VLAN configuration consistency by managing the addition, deletion, and renaming of VLANs on a network-wide basis. VTP minimizes misconfigurations and configuration inconsistencies that can cause several problems, such as duplicate VLAN names, incorrect VLAN-type specifications, and security violations.

VTP functionality is supported across the stack, and all devices in the stack maintain the same VLAN and VTP configuration inherited from the active device. When a device learns of a new VLAN through VTP

messages or when a new VLAN is configured by the user, the new VLAN information is communicated to all devices in the stack.

When a device joins the stack or when stacks merge, the new devices get VTP information from the active device.

## VTP Domain

A VTP domain (also called a VLAN management domain) consists of one device or several interconnected devices or device stacks under the same administrative responsibility sharing the same VTP domain name. A device can be in only one VTP domain. You make global VLAN configuration changes for the domain.

By default, the device is in the VTP no-management-domain state until it receives an advertisement for a domain over a trunk link (a link that carries the traffic of multiple VLANs) or until you configure a domain name. Until the management domain name is specified or learned, you cannot create or modify VLANs on a VTP server, and VLAN information is not propagated over the network.

If the device receives a VTP advertisement over a trunk link, it inherits the management domain name and the VTP configuration revision number. The device then ignores advertisements with a different domain name or an earlier configuration revision number.

When you make a change to the VLAN configuration on a VTP server, the change is propagated to all devices in the VTP domain. VTP advertisements are sent over all IEEE trunk connections, including IEEE 802.1Q. VTP dynamically maps VLANs with unique names and internal index associates across multiple LAN types. Mapping eliminates excessive device administration required from network administrators.

If you configure a device for VTP transparent mode, you can create and modify VLANs, but the changes are not sent to other devices in the domain, and they affect only the individual device. However, configuration changes made when the device is in this mode are saved in the device running configuration and can be saved to the device startup configuration file.

### Related Topics

[Adding a VTP Client to a VTP Domain \(CLI\)](#), on page 2777

[Prerequisites for VTP](#), on page 2759

[Mapping Secondary VLANs to a Primary VLAN Layer 3 VLAN Interface](#), on page 2854

[Example: Mapping Secondary VLANs to a Primary VLAN Interface](#), on page 2858

## VTP Modes

Table 224: VTP Modes

VTP Mode	Description
VTP server	<p>In VTP server mode, you can create, modify, and delete VLANs, and specify other configuration parameters (such as the VTP version) for the entire VTP domain. VTP servers advertise their VLAN configurations to other devices in the same VTP domain and synchronize their VLAN configurations with other devices based on advertisements received over trunk links.</p> <p>VTP server is the default mode.</p> <p>In VTP server mode, VLAN configurations are saved in NVRAM. If the device detects a failure while writing a configuration to NVRAM, VTP mode automatically changes from server mode to client mode. If this happens, the device cannot be returned to VTP server mode until the NVRAM is functioning.</p>
VTP client	<p>A VTP client functions like a VTP server and transmits and receives VTP updates on its trunks, but you cannot create, change, or delete VLANs on a VTP client. VLANs are configured on another device in the domain that is in server mode.</p> <p>In VTP versions 1 and 2 in VTP client mode, VLAN configurations are not saved in NVRAM. In VTP version 3, VLAN configurations are saved in NVRAM in client mode.</p>



VTP Mode	Description
VTP transparent	<p>VTP transparent devices do not participate in VTP. A VTP transparent device does not advertise its VLAN configuration and does not synchronize its VLAN configuration based on received advertisements. However, in VTP version 2 or version 3, transparent devices do forward VTP advertisements that they receive from other devices through their trunk interfaces. You can create, modify, and delete VLANs on a device in VTP transparent mode.</p> <p>When the device is in VTP transparent mode, the VTP and VLAN configurations are saved in NVRAM, but they are not advertised to other devices. In this mode, VTP mode and domain name are saved in the device running configuration, and you can save this information in the device startup configuration file by using the <b>copy running-config startup-config</b> privileged EXEC command.</p> <p>In a device stack, the running configuration and the saved configuration are the same for all devices in a stack.</p>
VTP off	<p>A device in VTP off mode functions in the same manner as a VTP transparent device, except that it does not forward VTP advertisements on trunks.</p>

#### Related Topics

[Prerequisites for VTP](#), on page 2759

[Configuring VTP Mode \(CLI\)](#), on page 2769

## VTP Advertisements

Each device in the VTP domain sends periodic global configuration advertisements from each trunk port to a reserved multicast address. Neighboring devices receive these advertisements and update their VTP and VLAN configurations as necessary.

VTP advertisements distribute this global domain information:

- VTP domain name
- VTP configuration revision number
- Update identity and update timestamp
- MD5 digest VLAN configuration, including maximum transmission unit (MTU) size for each VLAN
- Frame format

VTP advertisements distribute this VLAN information for each configured VLAN:

- VLAN IDs (including IEEE 802.1Q)

- VLAN name
- VLAN type
- VLAN state
- Additional VLAN configuration information specific to the VLAN type

In VTP version 3, VTP advertisements also include the primary server ID, an instance number, and a start index.

#### Related Topics

[Prerequisites for VTP](#), on page 2759

## VTP Version 2

If you use VTP in your network, you must decide which version of VTP to use. By default, VTP operates in version 1.

VTP version 2 supports these features that are not supported in version 1:

- Token Ring support—VTP version 2 supports Token Ring Bridge Relay Function (TrBRF) and Token Ring Concentrator Relay Function (TrCRF) VLANs.
- Unrecognized Type-Length-Value (TLV) support—A VTP server or client propagates configuration changes to its other trunks, even for TLVs it is not able to parse. The unrecognized TLV is saved in NVRAM when the device is operating in VTP server mode.
- Version-Dependent Transparent Mode—In VTP version 1, a VTP transparent device inspects VTP messages for the domain name and version and forwards a message only if the version and domain name match. Although VTP version 2 supports only one domain, a VTP version 2 transparent device forwards a message only when the domain name matches.
- Consistency Checks—In VTP version 2, VLAN consistency checks (such as VLAN names and values) are performed only when you enter new information through the CLI or SNMP. Consistency checks are not performed when new information is obtained from a VTP message or when information is read from NVRAM. If the MD5 digest on a received VTP message is correct, its information is accepted.

#### Related Topics

[Enabling the VTP Version \(CLI\)](#), on page 2773

## VTP Version 3

VTP version 3 supports these features that are not supported in version 1 or version 2:

- Enhanced authentication—You can configure the authentication as **hidden** or **secret**. When **hidden**, the secret key from the password string is saved in the VLAN database file, but it does not appear in plain text in the configuration. Instead, the key associated with the password is saved in hexadecimal format in the running configuration. You must reenter the password if you enter a takeover command in the domain. When you enter the **secret** keyword, you can directly configure the password secret key.
- Support for extended range VLAN (VLANs 1006 to 4094) database propagation—VTP versions 1 and 2 propagate only VLANs 1 to 1005.



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**Note** VTP pruning still applies only to VLANs 1 to 1005, and VLANs 1002 to 1005 are still reserved and cannot be modified.

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- Support for any database in a domain—In addition to propagating VTP information, version 3 can propagate Multiple Spanning Tree (MST) protocol database information. A separate instance of the VTP protocol runs for each application that uses VTP.
- VTP primary server and VTP secondary servers—A VTP primary server updates the database information and sends updates that are honored by all devices in the system. A VTP secondary server can only back up the updated VTP configurations received from the primary server to its NVRAM.

By default, all devices come up as secondary servers. You can enter the **vtp primary** privileged EXEC command to specify a primary server. Primary server status is only needed for database updates when the administrator issues a takeover message in the domain. You can have a working VTP domain without any primary servers. Primary server status is lost if the device reloads or domain parameters change, even when a password is configured on the device.

- With VTP version 3 in server mode the VLAN configuration is saved into vlan.dat file. VLAN configuration is not saved in NVRAM as is the case in the transparent mode. While taking a backup of the switch configuration, you also have to take a backup of the vlan.dat file.



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**Note** VTP versions 1 and 2 are capable of publishing only standard VLANs (VLANs 1 to 1001) and extended VLANs (VLANs 1006 to 4094) are stored locally in the flash drive or the running configuration. VTP version 3 is capable of publishing extended VLANs to the entire VTP domain and extended VLANs are not stored locally.

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#### Related Topics

[Enabling the VTP Version \(CLI\)](#), on page 2773

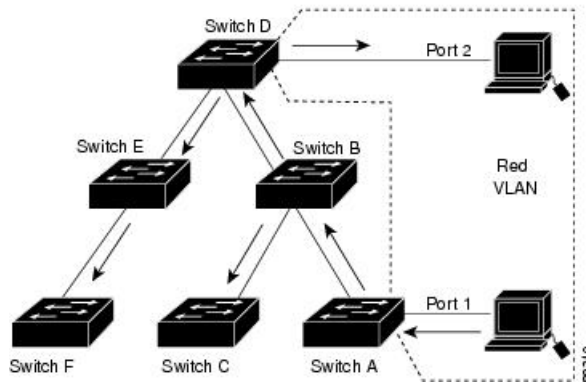
## VTP Pruning

VTP pruning increases network available bandwidth by restricting flooded traffic to those trunk links that the traffic must use to reach the destination devices. Without VTP pruning, a device floods broadcast, multicast, and unknown unicast traffic across all trunk links within a VTP domain even though receiving devices might discard them. VTP pruning is disabled by default.

VTP pruning blocks unneeded flooded traffic to VLANs on trunk ports that are included in the pruning-eligible list. Only VLANs included in the pruning-eligible list can be pruned. By default, VLANs 2 through 1001 are pruning eligible device trunk ports. If the VLANs are configured as pruning-ineligible, the flooding continues. VTP pruning is supported in all VTP versions.

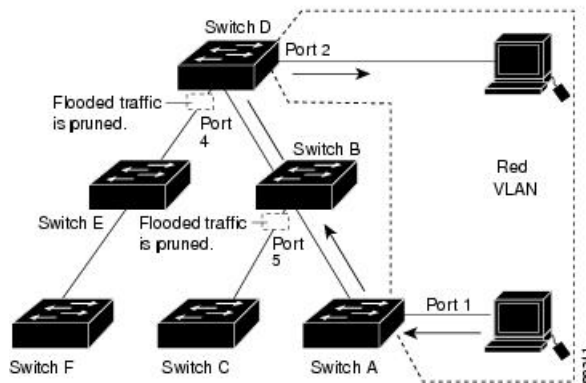
**Figure 147: Flooding Traffic without VTP Pruning**

VTP pruning is disabled in the switched network. Port 1 on Device A and Port 2 on Device D are assigned to the Red VLAN. If a broadcast is sent from the host connected to Device A, Device A floods the broadcast and every device in the network receives it, even though Devices C, E, and F have no ports in the Red VLAN.



**Figure 148: Optimized Flooded Traffic VTP Pruning**

VTP pruning is enabled in the switched network. The broadcast traffic from Device A is not forwarded to Devices C, E, and F because traffic for the Red VLAN has been pruned on the links shown (Port 5 on Device B and Port 4 on Device D).



With VTP versions 1 and 2, when you enable pruning on the VTP server, it is enabled for the entire VTP domain. In VTP version 3, you must manually enable pruning on each device in the domain. Making VLANs pruning-eligible or pruning-ineligible affects pruning eligibility for those VLANs on that trunk only (not on all devices in the VTP domain).

VTP pruning takes effect several seconds after you enable it. VTP pruning does not prune traffic from VLANs that are pruning-ineligible. VLAN 1 and VLANs 1002 to 1005 are always pruning-ineligible; traffic from these VLANs cannot be pruned. Extended-range VLANs (VLAN IDs higher than 1005) are also pruning-ineligible.

### Related Topics

[Enabling VTP Pruning \(CLI\)](#), on page 2775

## VTP and Device Stacks

VTP configuration is the same in all members of a device stack. When the device stack is in VTP server, client, or transparent mode, all devices in the stack carry the same VTP configuration.

- When a device joins the stack, it inherits the VTP and VLAN properties of the active switch.
- All VTP updates are carried across the stack.

- When VTP mode is changed in a device in the stack, the other devices in the stack also change VTP mode, and the device VLAN database remains consistent.

VTP version 3 functions the same on a standalone device or a stack except when the device stack is the primary server for the VTP database. In this case, the MAC address of the active switch is used as the primary server ID. If the active device reloads or is powered off, a new active switch is elected.

- If you do not configure the persistent MAC address feature, when the new active device is elected, it sends a takeover message using the current stack MAC address.



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**Note** By default the persistent MAC address is on.

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## VTP Configuration Guidelines

### VTP Configuration Requirements

When you configure VTP, you must configure a trunk port so that the device can send and receive VTP advertisements to and from other devices in the domain.

### VTP Settings

The VTP information is saved in the VTP VLAN database. When VTP mode is transparent, the VTP domain name and mode are also saved in the device running configuration file, and you can save it in the device startup configuration file by entering the **copy running-config startup-config** privileged EXEC command. You must use this command if you want to save VTP mode as transparent, even if the device resets.

When you save VTP information in the device startup configuration file and reboot the device, the device configuration is selected as follows:

- If the VTP mode is transparent in the startup configuration and the VLAN database and the VTP domain name from the VLAN database matches that in the startup configuration file, the VLAN database is ignored (cleared), and the VTP and VLAN configurations in the startup configuration file are used. The VLAN database revision number remains unchanged in the VLAN database.
- If the VTP mode or domain name in the startup configuration do not match the VLAN database, the domain name and VTP mode and configuration for VLAN IDs 1 to 1005 use the VLAN database information.

#### Related Topics

[Configuring VTP on a Per-Port Basis \(CLI\)](#), on page 2776

[Configuring a VTP Version 3 Primary Server \(CLI\)](#), on page 2772

### Domain Names for Configuring VTP

When configuring VTP for the first time, you must always assign a domain name. You must configure all devices in the VTP domain with the same domain name. Devices in VTP transparent mode do not exchange VTP messages with other devices, and you do not need to configure a VTP domain name for them.



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**Note** If the NVRAM and DRAM storage is sufficient, all devices in a VTP domain should be in VTP server mode.

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**Caution** Do not configure a VTP domain if all devices are operating in VTP client mode. If you configure the domain, it is impossible to make changes to the VLAN configuration of that domain. Make sure that you configure at least one device in the VTP domain for VTP server mode.

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#### Related Topics

[Adding a VTP Client to a VTP Domain \(CLI\)](#), on page 2777

## Passwords for the VTP Domain

You can configure a password for the VTP domain, but it is not required. If you do configure a domain password, all domain devices must share the same password and you must configure the password on each device in the management domain. Devices without a password or with the wrong password reject VTP advertisements.

If you configure a VTP password for a domain, a device that is booted without a VTP configuration does not accept VTP advertisements until you configure it with the correct password. After the configuration, the device accepts the next VTP advertisement that uses the same password and domain name in the advertisement.

If you are adding a new device to an existing network with VTP capability, the new device learns the domain name only after the applicable password has been configured on it.



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**Caution** When you configure a VTP domain password, the management domain does not function properly if you do not assign a management domain password to each device in the domain.

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#### Related Topics

[Configuring a VTP Version 3 Password \(CLI\)](#), on page 2771

[Example: Configuring a Switch as the Primary Server](#), on page 2780

## VTP Version

Follow these guidelines when deciding which VTP version to implement:

- All devices in a VTP domain must have the same domain name, but they do not need to run the same VTP version.
- A VTP version 2-capable device can operate in the same VTP domain as a device running VTP version 1 if version 2 is disabled on the version 2-capable device (version 2 is disabled by default).
- If a device running VTP version 1, but capable of running VTP version 2, receives VTP version 3 advertisements, it automatically moves to VTP version 2.
- If a device running VTP version 3 is connected to a device running VTP version 1, the VTP version 1 device moves to VTP version 2, and the VTP version 3 device sends scaled-down versions of the VTP packets so that the VTP version 2 device can update its database.
- A device running VTP version 3 cannot move to version 1 or 2 if it has extended VLANs.

- Do not enable VTP version 2 on a device unless all of the devices in the same VTP domain are version-2-capable. When you enable version 2 on a device, all of the version-2-capable devices in the domain enable version 2. If there is a version 1-only device, it does not exchange VTP information with devices that have version 2 enabled.
- Cisco recommends placing VTP version 1 and 2 devices at the edge of the network because they do not forward VTP version 3 advertisements.
- If there are TrBRF and TrCRF Token Ring networks in your environment, you must enable VTP version 2 or version 3 for Token Ring VLAN switching to function properly. To run Token Ring and Token Ring-Net, disable VTP version 2.
- VTP version 1 and version 2 do not propagate configuration information for extended range VLANs (VLANs 1006 to 4094). You must configure these VLANs manually on each device. VTP version 3 supports extended-range VLANs and support for extended range VLAN database propagation.
- When a VTP version 3 device trunk port receives messages from a VTP version 2 device, it sends a scaled-down version of the VLAN database on that particular trunk in VTP version 2 format. A VTP version 3 device does not send VTP version 2-formatted packets on a trunk unless it first receives VTP version 2 packets on that trunk port.
- When a VTP version 3 device detects a VTP version 2 device on a trunk port, it continues to send VTP version 3 packets, in addition to VTP version 2 packets, to allow both kinds of neighbors to coexist on the same trunk.
- A VTP version 3 device does not accept configuration information from a VTP version 2 or version 1 device.
- Two VTP version 3 regions can only communicate in transparent mode over a VTP version 1 or version 2 region.
- Devices that are only VTP version 1 capable cannot interoperate with VTP version 3 devices.
- VTP version 1 and version 2 do not propagate configuration information for extended range VLANs (VLANs 1006 to 4094). You must manually configure these VLANs on each device.

#### Related Topics

[Enabling the VTP Version \(CLI\)](#), on page 2773

## How to Configure VTP

### Configuring VTP Mode (CLI)

You can configure VTP mode as one of these:

- VTP server mode—In VTP server mode, you can change the VLAN configuration and have it propagated throughout the network.
- VTP client mode—In VTP client mode, you cannot change its VLAN configuration. The client device receives VTP updates from a VTP server in the VTP domain and then modifies its configuration accordingly.

- VTP transparent mode—In VTP transparent mode, VTP is disabled on the device. The device does not send VTP updates and does not act on VTP updates received from other device. However, a VTP transparent device running VTP version 2 does forward received VTP advertisements on its trunk links.
- VTP off mode—VTP off mode is the same as VTP transparent mode except that VTP advertisements are not forwarded.

When you configure a domain name, it cannot be removed; you can only reassign a device to a different domain.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>vtp domain <i>domain-name</i></b> <b>Example:</b> Device(config)# <b>vtp domain eng_group</b>	Configures the VTP administrative-domain name. The name can be 1 to 32 characters. All devices operating in VTP server or client mode under the same administrative responsibility must be configured with the same domain name.  This command is optional for modes other than server mode. VTP server mode requires a domain name. If the device has a trunk connection to a VTP domain, the device learns the domain name from the VTP server in the domain.  You should configure the VTP domain before configuring other VTP parameters.
<b>Step 4</b>	<b>vtp mode {client   server   transparent   off} {vlan   mst   unknown}</b> <b>Example:</b> Device(config)# <b>vtp mode server</b>	Configures the device for VTP mode (client, server, transparent, or off). <ul style="list-style-type: none"> <li>• <b>vlan</b>—The VLAN database is the default if none are configured.</li> <li>• <b>mst</b>—The multiple spanning tree (MST) database.</li> <li>• <b>unknown</b>—An unknown database type.</li> </ul>



	Command or Action	Purpose
<b>Step 5</b>	<b>vtp password</b> <i>password</i> <b>Example:</b> Device(config)# <b>vtp password mypassword</b>	(Optional) Sets the password for the VTP domain. The password can be 8 to 64 characters. If you configure a VTP password, the VTP domain does not function properly if you do not assign the same password to each device in the domain.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show vtp status</b> <b>Example:</b> Device# <b>show vtp status</b>	Verifies your entries in the <i>VTP Operating Mode</i> and the <i>VTP Domain Name</i> fields of the display.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves the configuration in the startup configuration file.  Only VTP mode and domain name are saved in the device running configuration and can be copied to the startup configuration file.

**Related Topics**

[VTP Modes](#), on page 2762

## Configuring a VTP Version 3 Password (CLI)

You can configure a VTP version 3 password on the device.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>vtp version 3</b> <b>Example:</b> <pre>Device(config)# vtp version 3</pre>	Enables VTP version 3 on the device. The default is VTP version 1.
<b>Step 4</b>	<b>vtp password <i>password</i> [hidden   secret]</b> <b>Example:</b> <pre>Device(config)# vtp password mypassword hidden</pre>	(Optional) Sets the password for the VTP domain. The password can be 8 to 64 characters. <ul style="list-style-type: none"> <li>• (Optional) <b>hidden</b>—Saves the secret key generated from the password string in the nvram:vlan.dat file. If you configure a takeover by configuring a VTP primary server, you are prompted to reenter the password.</li> <li>• (Optional) <b>secret</b>—Directly configures the password. The secret password must contain 32 hexadecimal characters.</li> </ul>
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show vtp password</b> <b>Example:</b> <pre>Device# show vtp password</pre>	Verifies your entries. The output appears like this: <pre>VTP password: 89914640C8D90868B6A0D8103847A733</pre>
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Passwords for the VTP Domain](#), on page 2768

[Example: Configuring a Switch as the Primary Server](#), on page 2780

## Configuring a VTP Version 3 Primary Server (CLI)

When you configure a VTP server as a VTP primary server, the takeover operation starts.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>vtp version 3</b> <b>Example:</b> Device(config)# <b>vtp version 3</b>	Enables VTP version 3 on the device. The default is VTP version 1.
<b>Step 2</b>	<b>vtp primary [vlan   mst] [force]</b> <b>Example:</b> Device# <b>vtp primary vlan force</b>	Changes the operational state of a device from a secondary server (the default) to a primary server and advertises the configuration to the domain. If the device password is configured as <b>hidden</b> , you are prompted to reenter the password. <ul style="list-style-type: none"> <li>• (Optional) <b>vlan</b>—Selects the VLAN database as the takeover feature. This is the default.</li> <li>• (Optional) <b>mst</b>—Selects the multiple spanning tree (MST) database as the takeover feature.</li> <li>• (Optional) <b>force</b>—Overwrites the configuration of any conflicting servers. If you do not enter <b>force</b>, you are prompted for confirmation before the takeover.</li> </ul>

**Related Topics**

[VTP Settings](#), on page 2767

## Enabling the VTP Version (CLI)

VTP version 2 and version 3 are disabled by default.

- When you enable VTP version 2 on a device, every VTP version 2-capable device in the VTP domain enables version 2. To enable VTP version 3, you must manually configure it on each device.
- With VTP versions 1 and 2, you can configure the version only on devices in VTP server or transparent mode. If a device is running VTP version 3, you can change to version 2 when the device is in client mode if no extended VLANs exist, and no hidden password was configured.



**Caution** VTP version 1 and VTP version 2 are not interoperable on devices in the same VTP domain. Do not enable VTP version 2 unless every device in the VTP domain supports version 2.

- In TrCRF and TrBRF Token Ring environments, you must enable VTP version 2 or VTP version 3 for Token Ring VLAN switching to function properly. For Token Ring and Token Ring-Net media, disable VTP version 2.



**Caution** In VTP version 3, both the primary and secondary servers can exist on an instance in the domain.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>vtp version {1   2   3}</b> <b>Example:</b> Device(config)# <b>vtp version 2</b>	Enables the VTP version on the device. The default is VTP version 1.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show vtp status</b> <b>Example:</b> Device# <b>show vtp status</b>	Verifies that the configured VTP version is enabled.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

### Related Topics

[VTP Version](#), on page 2768

[VTP Version 2](#), on page 2764

[VTP Version 3](#), on page 2764

## Enabling VTP Pruning (CLI)

### Before you begin

VTP pruning is not designed to function in VTP transparent mode. If one or more devices in the network are in VTP transparent mode, you should do one of these actions:

- Turn off VTP pruning in the entire network.
- Turn off VTP pruning by making all VLANs on the trunk of the device upstream to the VTP transparent device pruning ineligible.

To configure VTP pruning on an interface, use the **switchport trunk pruning vlan** interface configuration command. VTP pruning operates when an interface is trunking. You can set VLAN pruning-eligibility, whether or not VTP pruning is enabled for the VTP domain, whether or not any given VLAN exists, and whether or not the interface is currently trunking.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>vtp pruning</b> <b>Example:</b> Device(config)# <b>vtp pruning</b>	Enables pruning in the VTP administrative domain.  By default, pruning is disabled. You need to enable pruning on only one device in VTP server mode.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show vtp status</b> <b>Example:</b>	Verifies your entries in the <i>VTP Pruning Mode</i> field of the display.

	Command or Action	Purpose
	Device# <code>show vtp status</code>	

**Related Topics**

[VTP Pruning](#), on page 2765

## Configuring VTP on a Per-Port Basis (CLI)

With VTP version 3, you can enable or disable VTP on a per-port basis. You can enable VTP only on ports that are in trunk mode. Incoming and outgoing VTP traffic are blocked, not forwarded.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <code>interface gigabitethernet0/1</code>	Identifies an interface, and enters interface configuration mode.
<b>Step 4</b>	<b>vtp</b> <b>Example:</b> Device(config-if)# <code>vtp</code>	Enables VTP on the specified port.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show running-config interface <i>interface-id</i></b> <b>Example:</b>	Verifies the change to the port.

	Command or Action	Purpose
	Device# <code>show running-config interface gigabitethernet 1/0/1</code>	
<b>Step 7</b>	<b>show vtp status</b> <b>Example:</b> Device# <code>show vtp status</code>	Verifies the configuration.

**Related Topics**

[VTP Settings](#), on page 2767

## Adding a VTP Client to a VTP Domain (CLI)

Follow these steps to verify and reset the VTP configuration revision number on a device *before* adding it to a VTP domain.

**Before you begin**

Before adding a VTP client to a VTP domain, always verify that its VTP configuration revision number is *lower* than the configuration revision number of the other devices in the VTP domain. Devices in a VTP domain always use the VLAN configuration of the device with the highest VTP configuration revision number. With VTP versions 1 and 2, adding a device that has a revision number higher than the revision number in the VTP domain can erase all VLAN information from the VTP server and VTP domain. With VTP version 3, the VLAN information is not erased.

You can use the `vtp mode transparent` global configuration command to disable VTP on the device and then to change its VLAN information without affecting the other devices in the VTP domain.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>show vtp status</b> <b>Example:</b> Device# <code>show vtp status</code>	Checks the VTP configuration revision number. If the number is 0, add the device to the VTP domain. If the number is greater than 0, follow these substeps: <ul style="list-style-type: none"> <li>• Write down the domain name.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• Write down the configuration revision number.</li> <li>• Continue with the next steps to reset the device configuration revision number.</li> </ul>
<b>Step 3</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 4</b>	<b>vtp domain <i>domain-name</i></b> <b>Example:</b> Device (config)# <b>vtp domain domain123</b>	Changes the domain name from the original one displayed in Step 1 to a new name.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device (config)# <b>end</b>	Returns to privileged EXEC mode. The VLAN information on the device is updated and the configuration revision number is reset to 0.
<b>Step 6</b>	<b>show vtp status</b> <b>Example:</b> Device# <b>show vtp status</b>	Verifies that the configuration revision number has been reset to 0.
<b>Step 7</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 8</b>	<b>vtp domain <i>domain-name</i></b> <b>Example:</b> Device (config)# <b>vtp domain domain012</b>	Enters the original domain name on the device
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device (config)# <b>end</b>	Returns to privileged EXEC mode. The VLAN information on the device is updated.



	Command or Action	Purpose
<b>Step 10</b>	<b>show vtp status</b> <b>Example:</b> Device# <code>show vtp status</code>	(Optional) Verifies that the domain name is the same as in Step 1 and that the configuration revision number is 0.

#### Related Topics

[VTP Domain](#), on page 2761

[Prerequisites for VTP](#), on page 2759

[Domain Names for Configuring VTP](#), on page 2767

## Monitoring VTP

This section describes commands used to display and monitor the VTP configuration.

You monitor VTP by displaying VTP configuration information: the domain name, the current VTP revision, and the number of VLANs. You can also display statistics about the advertisements sent and received by the device.

**Table 225: VTP Monitoring Commands**

Command	Purpose
<code>show vtp counters</code>	Displays counters about VTP messages that have been sent and received.
<code>show vtp devices [conflict]</code>	Displays information about all VTP version 3 devices in the domain. Conflicts are VTP version 3 devices with conflicting primary servers. The <b>show vtp devices</b> command does not display information when the device is in transparent or off mode.
<code>show vtp interface [interface-id]</code>	Displays VTP status and configuration for all interfaces or the specified interface.
<code>show vtp password</code>	Displays the VTP password. The form of the password displayed depends on whether or not the <b>hidden</b> keyword was entered and if encryption is enabled on the device.
<code>show vtp status</code>	Displays the VTP device configuration information.

# Configuration Examples for VTP

## Example: Configuring a Switch as the Primary Server

This example shows how to configure a device as the primary server for the VLAN database (the default) when a hidden or secret password was configured:

```
Device# vtp primary vlan
Enter VTP password: mypassword
This switch is becoming Primary server for vlan feature in the VTP domain

VTP Database Conf Switch ID      Primary Server Revision System Name
-----
VLANDB          Yes  00d0.00b8.1400=00d0.00b8.1400 1          stp7

Do you want to continue (y/n) [n]? y
```

### Related Topics

- [Configuring a VTP Version 3 Password \(CLI\)](#), on page 2771
- [Passwords for the VTP Domain](#), on page 2768

## Where to Go Next

After configuring VTP, you can configure the following:

- VLANs
- VLAN groups
- VLAN trunking
- Voice VLANs

## Additional References

### Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	<i>VLAN Command Reference (Catalyst 3850 Switches)</i> <i>Layer 2/3 Command Reference (Catalyst 3850 Switches)</i>
Additional configuration commands and procedures.	<i>LAN Switching Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i> <i>Layer 2/3 Configuration Guide (Catalyst 3850 Switches)</i>

**Error Message Decoder**

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**Standards and RFCs**

Standard/RFC	Title
RFC 1573	Evolution of the Interfaces Group of MIB-II
RFC 1757	Remote Network Monitoring Management
RFC 2021	SNMPv2 Management Information Base for the Transmission Control Protocol using SMIv2

**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for VTP

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.





## CHAPTER 155

# VLANs

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- [Finding Feature Information, on page 2783](#)
- [Prerequisites for VLANs, on page 2783](#)
- [Restrictions for VLANs, on page 2784](#)
- [Information About VLANs, on page 2784](#)
- [How to Configure VLANs, on page 2788](#)
- [Monitoring VLANs, on page 2796](#)
- [Where to Go Next, on page 2797](#)
- [Additional References, on page 2798](#)
- [Feature History and Information for VLANs, on page 2799](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for VLANs

The following are prerequisites and considerations for configuring VLANs:

- Before you create VLANs, you must decide whether to use VLAN Trunking Protocol (VTP) to maintain global VLAN configuration for your network.
- If you plan to configure many VLANs on the device and to not enable routing, you can set the Switch Database Management (SDM) feature to the VLAN template, which configures system resources to support the maximum number of unicast MAC addresses.
- Devices running the LAN Base feature set support only static routing on SVIs.
- A VLAN should be present in the device to be able to add it to the VLAN group.

## Restrictions for VLANs

The following are restrictions for VLANs:

- In the Cisco Catalyst 4500E Supervisor Engine, the number of device per-VLAN spanning-tree (PVST) or rapid PVST is based on the number of trunks on the switch multiplied by the number of active VLANs on the trunks, plus the number of non-trunking interfaces on the switch (trunks \* VLANs + non-trunk ports). For MSTP, the maximum number of MST instances supported is 4094.
- The device supports IEEE 802.1Q trunking methods for sending VLAN traffic over Ethernet ports.
- Configuring an interface VLAN router's MAC address is not supported. The interface VLAN already has an MAC address assigned by default.
- You cannot have a switch stack containing a mix of Catalyst 3850 and Catalyst 3650 switches.

## Information About VLANs

### Logical Networks

A VLAN is a switched network that is logically segmented by function, project team, or application, without regard to the physical locations of the users. VLANs have the same attributes as physical LANs, but you can group end stations even if they are not physically located on the same LAN segment. Any device port can belong to a VLAN, and unicast, broadcast, and multicast packets are forwarded and flooded only to end stations in the VLAN. Each VLAN is considered a logical network, and packets destined for stations that do not belong to the VLAN must be forwarded through a router or a device supporting fallback bridging. In a device stack, VLANs can be formed with ports across the stack. Because a VLAN is considered a separate logical network, it contains its own bridge Management Information Base (MIB) information and can support its own implementation of spanning tree.

VLANs are often associated with IP subnetworks. For example, all the end stations in a particular IP subnet belong to the same VLAN. Interface VLAN membership on the device is assigned manually on an interface-by-interface basis. When you assign device interfaces to VLANs by using this method, it is known as interface-based, or static, VLAN membership.

Traffic between VLANs must be routed.

The device can route traffic between VLANs by using device virtual interfaces (SVIs). An SVI must be explicitly configured and assigned an IP address to route traffic between VLANs.

### Supported VLANs

The device supports VLANs in VTP client, server, and transparent modes. VLANs are identified by a number from 1 to 4094. VLAN 1 is the default VLAN and is created during system initialization. VLAN IDs 1002 through 1005 are reserved for Token Ring and FDDI VLANs. All of the VLANs except 1002 to 1005 are available for user configuration.

There are 3 VTP versions: VTP version 1, version 2, and version 3. All VTP versions support both normal and extended range VLANs, but only with VTP version 3, does the device propagate extended range VLAN configuration information. When extended range VLANs are created in VTP versions 1 and 2, their

configuration information is not propagated. Even the local VTP database entries on the device are not updated, but the extended range VLANs configuration information is created and stored in the running configuration file.

You can configure up to 4049 VLANs on the device.

#### Related Topics

[Creating or Modifying an Ethernet VLAN \(CLI\)](#), on page 2789

[Deleting a VLAN \(CLI\)](#), on page 2791

[Assigning Static-Access Ports to a VLAN \(CLI\)](#), on page 2792

[Monitoring VLANs](#), on page 2796

[Creating an Extended-Range VLAN \(CLI\)](#), on page 2794

[Creating an Extended-Range VLAN with an Internal VLAN ID](#)

## VLAN Port Membership Modes

You configure a port to belong to a VLAN by assigning a membership mode that specifies the kind of traffic the port carries and the number of VLANs to which it can belong.

When a port belongs to a VLAN, the device learns and manages the addresses associated with the port on a per-VLAN basis.

*Table 226: Port Membership Modes and Characteristics*

Membership Mode	VLAN Membership Characteristics	VTP Characteristics
Static-access	A static-access port can belong to one VLAN and is manually assigned to that VLAN.	VTP is not required. If you do not want VTP to globally propagate information, set the VTP mode to transparent. To participate in VTP, there must be at least one trunk port on the device or the device stack connected to a trunk port of a second device or device stack.
Trunk (IEEE 802.1Q) : <ul style="list-style-type: none"> <li>• IEEE 802.1Q— Industry-standard trunking encapsulation.</li> </ul>	A trunk port is a member of all VLANs by default, including extended-range VLANs, but membership can be limited by configuring the allowed-VLAN list. You can also modify the pruning-eligible list to block flooded traffic to VLANs on trunk ports that are included in the list.	VTP is recommended but not required. VTP maintains VLAN configuration consistency by managing the addition, deletion, and renaming of VLANs on a network-wide basis. VTP exchanges VLAN configuration messages with other devices over trunk links.
Voice VLAN	A voice VLAN port is an access port attached to a Cisco IP Phone, configured to use one VLAN for voice traffic and another VLAN for data traffic from a device attached to the phone.	VTP is not required; it has no effect on a voice VLAN.

**Related Topics**

- [Assigning Static-Access Ports to a VLAN \(CLI\)](#), on page 2792
- [Monitoring VLANs](#), on page 2796

## VLAN Configuration Files

Configurations for VLAN IDs 1 to 1005 are written to the `vlan.dat` file (VLAN database), and you can display them by entering the **show vlan** privileged EXEC command. The `vlan.dat` file is stored in flash memory. If the VTP mode is transparent, they are also saved in the device running configuration file.

In a device stack, the whole stack uses the same `vlan.dat` file and running configuration. On some devices, the `vlan.dat` file is stored in flash memory on the active device.

You use the interface configuration mode to define the port membership mode and to add and remove ports from VLANs. The results of these commands are written to the running-configuration file, and you can display the file by entering the **show running-config** privileged EXEC command.

When you save VLAN and VTP information (including extended-range VLAN configuration information) in the startup configuration file and reboot the device, the device configuration is selected as follows:

- If the VTP mode is transparent in the startup configuration, and the VLAN database and the VTP domain name from the VLAN database matches that in the startup configuration file, the VLAN database is ignored (cleared), and the VTP and VLAN configurations in the startup configuration file are used. The VLAN database revision number remains unchanged in the VLAN database.
- If the VTP mode or domain name in the startup configuration does not match the VLAN database, the domain name and VTP mode and configuration for the VLAN IDs 1 to 1005 use the VLAN database information.
- In VTP versions 1 and 2, if VTP mode is server, the domain name and VLAN configuration for VLAN IDs 1 to 1005 use the VLAN database information. VTP version 3 also supports VLANs 1006 to 4094.

**Note**

Ensure that you delete the `vlan.dat` file along with the configuration files before you reset the switch configuration using **write erase** command. This ensures that the switch reboots correctly on a reset.

## Normal-Range VLAN Configuration Guidelines

Normal-range VLANs are VLANs with IDs from 1 to 1005.

Follow these guidelines when creating and modifying normal-range VLANs in your network:

- Normal-range VLANs are identified with a number between 1 and 1001. VLAN numbers 1002 through 1005 are reserved for Token Ring and FDDI VLANs.
- VLAN configurations for VLANs 1 to 1005 are always saved in the VLAN database. If the VTP mode is transparent, VTP and VLAN configurations are also saved in the device running configuration file.
- If the device is in VTP server or VTP transparent mode, you can add, modify or remove configurations for VLANs 2 to 1001 in the VLAN database. (VLAN IDs 1 and 1002 to 1005 are automatically created and cannot be removed.)



- Extended-range VLANs created in VTP transparent mode are not saved in the VLAN database and are not propagated. VTP version 3 supports extended range VLAN (VLANs 1006 to 4094) database propagation in VTP server mode.
- Before you can create a VLAN, the device must be in VTP server mode or VTP transparent mode. If the device is a VTP server, you must define a VTP domain or VTP will not function.
- The device does not support Token Ring or FDDI media. The device does not forward FDDI, FDDI-Net, TrCRF, or TrBRF traffic, but it does propagate the VLAN configuration through VTP.
- The device supports 128 spanning tree instances. If a device has more active VLANs than supported spanning-tree instances, spanning tree can be enabled on 128 VLANs and is disabled on the remaining VLANs.

If you have already used all available spanning-tree instances on a device, adding another VLAN anywhere in the VTP domain creates a VLAN on that device that is not running spanning-tree. If you have the default allowed list on the trunk ports of that device (which is to allow all VLANs), the new VLAN is carried on all trunk ports. Depending on the topology of the network, this could create a loop in the new VLAN that would not be broken, particularly if there are several adjacent devices that all have run out of spanning-tree instances. You can prevent this possibility by setting allowed lists on the trunk ports of devices that have used up their allocation of spanning-tree instances.

If the number of VLANs on the device exceeds the number of supported spanning-tree instances, we recommend that you configure the IEEE 802.1s Multiple STP (MSTP) on your device to map multiple VLANs to a single spanning-tree instance.

- When a device in a stack learns a new VLAN or deletes or modifies an existing VLAN (either through VTP over network ports or through the CLI), the VLAN information is communicated to all stack members.
- When a device joins a stack or when stacks merge, VTP information (the vlan.dat file) on the new devices will be consistent with the active device.

#### Related Topics

[Creating or Modifying an Ethernet VLAN \(CLI\)](#), on page 2789

[Deleting a VLAN \(CLI\)](#), on page 2791

[Assigning Static-Access Ports to a VLAN \(CLI\)](#), on page 2792

[Monitoring VLANs](#), on page 2796

## Extended-Range VLAN Configuration Guidelines

Extended-range VLANs are VLANs with IDs from 1006 to 4094.

Follow these guidelines when creating extended-range VLANs:

- VLAN IDs in the extended range are not saved in the VLAN database and are not recognized by VTP unless the device is running VTP version 3.
- You cannot include extended-range VLANs in the pruning eligible range.
- For VTP version 1 or 2, you can set the VTP mode to transparent in global configuration mode. You should save this configuration to the startup configuration so that the device boots up in VTP transparent mode. Otherwise, you lose the extended-range VLAN configuration if the device resets. If you create extended-range VLANs in VTP version 3, you cannot convert to VTP version 1 or 2.

- In a device stack, the whole stack uses the same running configuration and saved configuration, and extended-range VLAN information is shared across the stack.

#### Related Topics

- [Creating an Extended-Range VLAN \(CLI\)](#), on page 2794
- [Creating an Extended-Range VLAN with an Internal VLAN ID](#)
- [Monitoring VLANs](#), on page 2796

## How to Configure VLANs

### How to Configure Normal-Range VLANs

You can set these parameters when you create a new normal-range VLAN or modify an existing VLAN in the VLAN database:

- VLAN ID
- VLAN name
- VLAN type
  - Ethernet
  - Fiber Distributed Data Interface [FDDI]
  - FDDI network entity title [NET]
  - TrBRF or TrCRF
  - Token Ring
  - Token Ring-Net
- VLAN state (active or suspended)
- Security Association Identifier (SAID)
- Bridge identification number for TrBRF VLANs
- Ring number for FDDI and TrCRF VLANs
- Parent VLAN number for TrCRF VLANs
- Spanning Tree Protocol (STP) type for TrCRF VLANs
- VLAN number to use when translating from one VLAN type to another

You can cause inconsistency in the VLAN database if you attempt to manually delete the `vlan.dat` file. If you want to modify the VLAN configuration, follow the procedures in this section.

## Creating or Modifying an Ethernet VLAN (CLI)

### Before you begin

With VTP version 1 and 2, if the device is in VTP transparent mode, you can assign VLAN IDs greater than 1006, but they are not added to the VLAN database.

The device supports only Ethernet interfaces. Because FDDI and Token Ring VLANs are not locally supported, you only configure FDDI and Token Ring media-specific characteristics for VTP global advertisements to other devices.

Although the device does not support Token Ring connections, a remote device with Token Ring connections could be managed from one of the supported devices. Devices running VTP Version 2 advertise information about these Token Ring VLANs:

- Token Ring TrBRF VLANs
- Token Ring TrCRF VLANs

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>vlan <i>vlan-id</i></b> <b>Example:</b> Device(config)# <b>vlan 20</b>	Enters a VLAN ID, and enters VLAN configuration mode. Enter a new VLAN ID to create a VLAN, or enter an existing VLAN ID to modify that VLAN.  <b>Note</b> The available VLAN ID range for this command is 1 to 4094.  Additional <b>vlan</b> command options include: <ul style="list-style-type: none"> <li>• <b>access-map</b>—Creates VLAN access-maps or enters the vlan access map command mode.</li> <li>• <b>configuration</b>—Enters the vlan feature configuration mode.</li> <li>• <b>dot1q</b>—Configures VLAN dot1q tag native parameters.</li> <li>• <b>filter</b>—Applies a VLAN filter map to a VLAN list.</li> <li>• <b>group</b>—Creates a VLAN group.</li> </ul>

	Command or Action	Purpose
Step 3	<p><b>name</b> <i>vlan-name</i></p> <p><b>Example:</b></p> <pre>Device(config-vlan)# name test20</pre>	<p>(Optional) Enters a name for the VLAN. If no name is entered for the VLAN, the default is to append the <i>vlan-id</i> value with leading zeros to the word VLAN. For example, VLAN0004 is a default VLAN name for VLAN 4.</p> <p>The following additional VLAN configuration command options are available:</p> <ul style="list-style-type: none"> <li>• <b>are</b>—Sets the maximum number of All Router Explorer (ARE) hops for the VLAN.</li> <li>• <b>backupcrf</b>—Enables or disables the backup concentrator relay function (CRF) mode for the VLAN.</li> <li>• <b>bridge</b>—Sets the value of the bridge number for the FDDI net or Token Ring net type VLANs.</li> <li>• <b>exit</b>—Applies changes, bumps the revision number, and exits.</li> <li>• <b>media</b>—Sets the media type of the VLAN.</li> <li>• <b>no</b>—Negates the command or default.</li> <li>• <b>parent</b>—Sets the value of the ID for the parent VLAN for FDDI or Token Ring type VLANs.</li> <li>• <b>remote-span</b>—Configures a remote SPAN VLAN.</li> <li>• <b>ring</b>—Sets the ring number value for FDDI or Token Ring type VLANs.</li> <li>• <b>said</b>—Sets the IEEE 802.10 SAID value.</li> <li>• <b>shutdown</b>—Shuts down the VLAN switching.</li> <li>• <b>state</b>—Sets the operational VLAN state to active or suspended.</li> <li>• <b>ste</b>—Sets the maximum number of Spanning Tree Explorer (STE) hops for the VLAN.</li> <li>• <b>stp</b>—Sets the Spanning Tree characteristics of the VLAN.</li> </ul>
Step 4	<p><b>media</b> { <b>ethernet</b>   <b>fd-net</b>   <b>fddi</b>   <b>tokenring</b>   <b>trn-net</b> }</p>	<p>Configures the VLAN media type. Command options include:</p>

	Command or Action	Purpose
	<b>Example:</b> Device(config-vlan) # <b>media ethernet</b>	<ul style="list-style-type: none"> <li>• <b>ethernet</b>—Sets the VLAN media type as Ethernet.</li> <li>• <b>fd-net</b>—Sets the VLAN media type as FDDI net.</li> <li>• <b>fdi</b>—Sets the VLAN media type as FDDI.</li> <li>• <b>tokenring</b>—Sets the VLAN media type as Token Ring.</li> <li>• <b>trn-net</b>—Sets the VLAN media type as Token Ring net.</li> </ul>
<b>Step 5</b>	<b>remote-span</b> <b>Example:</b> Device(config-vlan) # <b>remote-span</b>	(Optional) Configures the VLAN as the RSPAN VLAN for a remote SPAN session. For more information on remote SPAN, see the <i>Catalyst 3850 Network Management Configuration Guide</i> .
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show vlan {name vlan-name   id vlan-id}</b> <b>Example:</b> Device# <b>show vlan name test20 id 20</b>	Verifies your entries.

**Related Topics**

[Supported VLANs](#), on page 2784

[Normal-Range VLAN Configuration Guidelines](#), on page 2786

[Monitoring VLANs](#), on page 2796

**Deleting a VLAN (CLI)**

When you delete a VLAN from a device that is in VTP server mode, the VLAN is removed from the VLAN database for all devices in the VTP domain. When you delete a VLAN from a device that is in VTP transparent mode, the VLAN is deleted only on that specific device or a device stack.

You cannot delete the default VLANs for the different media types: Ethernet VLAN 1 and FDDI or Token Ring VLANs 1002 to 1005.

**Caution**

When you delete a VLAN, any ports assigned to that VLAN become inactive. They remain associated with the VLAN (and thus inactive) until you assign them to a new VLAN.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>no vlan <i>vlan-id</i></b> <b>Example:</b> Device(config)# <b>no vlan 4</b>	Removes the VLAN by entering the VLAN ID.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 5</b>	<b>show vlan brief</b> <b>Example:</b> Device# <b>show vlan brief</b>	Verifies the VLAN removal.
<b>Step 6</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Supported VLANs](#), on page 2784

[Normal-Range VLAN Configuration Guidelines](#), on page 2786

[Monitoring VLANs](#), on page 2796

**Assigning Static-Access Ports to a VLAN (CLI)**

You can assign a static-access port to a VLAN without having VTP globally propagate VLAN configuration information by disabling VTP (VTP transparent mode).

For the Cisco Catalyst 9500 Series Switches, if you are assigning a port on a cluster member device to a VLAN, first use the **rcommand** privileged EXEC command to log in to the cluster member switch.

If you assign an interface to a VLAN that does not exist, the new VLAN is created.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface</b> <b>gigabitethernet2/0/1</b>	Enters the interface to be added to the VLAN.
<b>Step 4</b>	<b>switchport mode access</b> <b>Example:</b> Device(config-if)# <b>switchport mode access</b>	Defines the VLAN membership mode for the port (Layer 2 access port).
<b>Step 5</b>	<b>switchport access vlan <i>vlan-id</i></b> <b>Example:</b> Device(config-if)# <b>switchport access vlan</b> <b>2</b>	Assigns the port to a VLAN. Valid VLAN IDs are 1 to 4094.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show running-config interface <i>interface-id</i></b> <b>Example:</b> Device# <b>show running-config interface</b>	Verifies the VLAN membership mode of the interface.

	Command or Action	Purpose
	<code>gigabitethernet2/0/1</code>	
<b>Step 8</b>	<b>show interfaces <i>interface-id</i> switchport</b> <b>Example:</b> <pre>Device# show interfaces gigabitethernet2/0/1 switchport</pre>	Verifies your entries in the <i>Administrative Mode</i> and the <i>Access Mode VLAN</i> fields of the display.
<b>Step 9</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Supported VLANs](#), on page 2784

[Normal-Range VLAN Configuration Guidelines](#), on page 2786

[Monitoring VLANs](#), on page 2796

[VLAN Port Membership Modes](#), on page 2785

## How to Configure Extended-Range VLANs

Extended-range VLANs enable service providers to extend their infrastructure to a greater number of customers. The extended-range VLAN IDs are allowed for any **switchport** commands that allow VLAN IDs.

With VTP version 1 or 2, extended-range VLAN configurations are not stored in the VLAN database, but because VTP mode is transparent, they are stored in the device running configuration file, and you can save the configuration in the startup configuration file. Extended-range VLANs created in VTP version 3 are stored in the VLAN database.

You can change only the MTU size and the remote SPAN configuration state on extended-range VLANs; all other characteristics must remain at the default state.

### Creating an Extended-Range VLAN (CLI)

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>



	Command or Action	Purpose
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>vlan <i>vlan-id</i></b> <b>Example:</b> Device(config)# <b>vlan 2000</b> Device(config-vlan)#	Enters an extended-range VLAN ID and enters VLAN configuration mode. The range is 1006 to 4094.
<b>Step 4</b>	<b>remote-span</b> <b>Example:</b> Device(config-vlan)# <b>remote-span</b>	(Optional) Configures the VLAN as the RSPAN VLAN.
<b>Step 5</b>	<b>exit</b> <b>Example:</b> Device(config-vlan)# <b>exit</b> Device(config)#	Returns to configuration mode.
<b>Step 6</b>	<b>interface vlan</b> <b>Example:</b> Device(config)# <b>interface vlan 200</b> Device(config-if)#	Enters the interface configuration mode for the selected VLAN.
<b>Step 7</b>	<b>ip mtu <i>mtu-size</i></b> <b>Example:</b> Device(config-if)# <b>ip mtu 1024</b> Device(config-if)#	(Optional) Modifies the VLAN by changing the MTU size. You can configure the MTU size between 68 to 1500 bytes.  <b>Note</b> Although all VLAN commands appear in the CLI help, only the <b>ip mtu <i>mtu-size</i></b> and <b>remote-span</b> commands are supported for extended-range VLANs.
<b>Step 8</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 9</b>	<b>show vlan id <i>vlan-id</i></b> <b>Example:</b> Device# <code>show vlan id 2000</code>	Verifies that the VLAN has been created.
<b>Step 10</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Supported VLANs](#), on page 2784

[Extended-Range VLAN Configuration Guidelines](#), on page 2787

[Monitoring VLANs](#), on page 2796

## Monitoring VLANs

*Table 227: Privileged EXEC show Commands*

Command	Purpose
<code>show interfaces [vlan <i>vlan-id</i>]</code>	Displays characteristics for all interfaces or for the specified VLAN configured on the device .

Command	Purpose
<b>show vlan</b> [ <b>access-map</b> <i>name</i>   <b>brief</b>   <b>dot1q</b> { <b>tag native</b> }   <b>filter</b> [ <b>access-map</b>   <b>vlan</b> ]   <b>group</b> [ <b>group-name</b> <i>name</i> ]   <b>id</b> <i>vlan-id</i>   <b>ifindex</b>   <b>mtu</b>   <b>name</b> <i>name</i>   <b>remote-span</b>   <b>summary</b> ]	Displays parameters for all VLANs or the specified VLAN on the device. The following command options are available: <ul style="list-style-type: none"> <li>• <b>access-map</b>—Displays the VLAN access-maps.</li> <li>• <b>brief</b>—Displays VTP VLAN status in brief.</li> <li>• <b>dot1q</b>—Displays the dot1q parameters.</li> <li>• <b>filter</b>—Displays VLAN filter information.</li> <li>• <b>group</b>—Displays the VLAN group with its name and the connected VLANs that are available.</li> <li>• <b>id</b>—Displays VTP VLAN status by identification number.</li> <li>• <b>ifindex</b>—Displays SNMP ifIndex.</li> <li>• <b>mtu</b>—Displays VLAN MTU information.</li> <li>• <b>name</b>—Displays the VTP VLAN information by specified name.</li> <li>• <b>remote-span</b>—Displays the remote SPAN VLANs.</li> <li>• <b>summary</b>—Displays a summary of VLAN information.</li> </ul>

### Related Topics

[Supported VLANs](#), on page 2784

[Normal-Range VLAN Configuration Guidelines](#), on page 2786

[Creating or Modifying an Ethernet VLAN \(CLI\)](#), on page 2789

[Deleting a VLAN \(CLI\)](#), on page 2791

[Assigning Static-Access Ports to a VLAN \(CLI\)](#), on page 2792

[Extended-Range VLAN Configuration Guidelines](#), on page 2787

[Creating an Extended-Range VLAN \(CLI\)](#), on page 2794

[Creating an Extended-Range VLAN with an Internal VLAN ID](#)

[VLAN Port Membership Modes](#), on page 2785

## Where to Go Next

After configuring VLANs, you can configure the following:

- VLAN groups
- VLAN Trunking Protocol (VTP)
- VLAN trunks
- Voice VLANs

# Additional References

## Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	<i>VLAN Command Reference (Catalyst 3850 Switches)</i> <i>Layer 2/3 Command Reference (Catalyst 3850 Switches)</i>
VLAN access-maps	<i>Security Configuration Guide (Catalyst 3850 Switches)</i> <i>Security Command Reference (Catalyst 3850 Switches)</i>
VLAN and Mobility Agents	<i>Mobility Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>
Cisco Flexible NetFlow	<i>Cisco Flexible NetFlow Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i> <i>Flexible Netflow Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>
IGMP Snooping	<i>IP Multicast Routing Command Reference (Catalyst 3850 Switches)</i> <i>IP Multicast Routing Configuration Guide (Catalyst 3850 Switches)</i>
IPv6	<i>IPv6 Configuration Guide (Catalyst 3850 Switches)</i> <i>IPv6 Command Reference (Catalyst 3850 Switches)</i>
SPAN	<i>Network Management Command Reference (Catalyst 3850 Switches)</i> <i>Network Management Configuration Guide (Catalyst 3850 Switches)</i>
Platform-independent configuration information	<i>Identity Based Networking Services Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>

## Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

## Standards and RFCs

Standard/RFC	Title
RFC 1573	Evolution of the Interfaces Group of MIB-II
RFC 1757	Remote Network Monitoring Management

Standard/RFC	Title
RFC 2021	SNMPv2 Management Information Base for the Transmission Control Protocol using SMIV2

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for VLANs

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced
Cisco IOS XE 3.3SE	VLAN GUI support.





## CHAPTER 156

# VLAN Groups

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- [Finding Feature Information, on page 2801](#)
- [Prerequisites for VLAN Groups, on page 2801](#)
- [Restrictions for VLAN Groups, on page 2801](#)
- [Information About VLAN Groups, on page 2802](#)
- [How to Configure VLAN Groups, on page 2802](#)
- [Where to Go Next, on page 2804](#)
- [Additional References, on page 2805](#)
- [Feature History and Information for VLAN Groups, on page 2806](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for VLAN Groups

- A VLAN should be present in the device for it to be added to the VLAN group.
- For a VLAN group to function properly, in addition to enabling DHCP snooping globally, you must ensure that DHCP snooping is enabled in all the VLANs.

## Restrictions for VLAN Groups

- The number of VLANs mapped to a VLAN group is not limited by Cisco IOS XE software release. However, if the number of VLANs in a VLAN group exceeds the recommended value of 32, the mobility functionality might not work as expected and in the VLAN group, L2 multicast breaks for some VLANs. Therefore, it is the responsibility of network administrators to configure feasible number of VLANs in

a VLAN group. When a VLAN is added to a VLAN group mapped to a WLAN which already has 32 VLANs, a warning is generated. But, when a new VLAN group is mapped to a WLAN with more than 32 VLANs, an error is generated.

For the VLAN Groups feature to work as expected, the VLANs mapped in a group must be present in the device. The static IP client behavior is not supported.

## Information About VLAN Groups

Whenever a client connects to a wireless network (WLAN), the client is placed in a VLAN that is associated with the WLAN. In a large venue, such as an auditorium, a stadium, or a conference room where there are numerous wireless clients, having only a single WLAN to accommodate many clients might be a challenge.

The VLAN Groups feature uses a single WLAN that can support multiple VLANs. The clients can get assigned to one of the configured VLANs. This feature maps a WLAN to a single VLAN or multiple VLANs using the VLAN groups. When a wireless client associates to the WLAN, the VLAN is derived by an algorithm based on the MAC address of the wireless client. A VLAN is assigned to the client and the client gets the IP address from the assigned VLAN. This feature also extends the current AP group architecture and AAA override architecture, where the AP groups and AAA override can override a VLAN or a VLAN group to which the WLAN is mapped.

When a client associates with a WLAN and the WLAN is applied to a VLAN group, an index is calculated based on the MAC address of the client and the number of VLANs in the VLAN group using a hash algorithm. Based on this index, a VLAN is assigned to the client. If the index is "dirty," another index is generated in a round-robin manner and the VLAN is assigned to the client based on the newly generated index.

The system marks VLAN as *Dirty* for 30 minutes when the clients are unable to receive IP addresses using DHCP. The system might not clear the *Dirty* flag from the VLAN even after 30 minutes for a VLAN group. After 30 minutes, when the VLAN is marked non-dirty, new clients in the IP Learn state can get assigned with IP addresses from the VLAN if free IPs are available in the pool and DHCP scope is defined correctly. This is the expected behavior because the timestamp of each interface has to be checked to see if it is greater than 30 minutes, due to which there is a lag of 5 minutes for the global timer to expire.

### Related Topics

[Creating a VLAN Group \(CLI\)](#), on page 2802

## How to Configure VLAN Groups

### Creating a VLAN Group (CLI)

#### Procedure

	Command or Action	Purpose
Step 1	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.



	Command or Action	Purpose
<b>Step 2</b>	<b>vlan group</b> <i>WORD</i> <b>vlan-list</b> <i>vlan-ID</i> <b>Example:</b> Device(config)#vlan group <b>vlangrp1</b> vlan-list <b>91-95</b>	Creates a VLAN group with the given group name (vlangrp1) and adds all the VLANs listed in the command. The VLAN list ranges from 1 to 4096 and the recommended number of VLANs in a group is 32.
<b>Step 3</b>	<b>end</b> <b>Example:</b> Device(config)#end	Exits the global configuration mode and returns to privileged EXEC mode. Alternatively, press <b>CTRL-Z</b> to exit the global configuration mode.

**Related Topics**

[Information About VLAN Groups](#), on page 2802

## Removing a VLAN Group (CLI)

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>vlan group</b> <i>WORD</i> <b>vlan-list</b> <i>vlan-ID</i> <b>Example:</b> Device(config)#vlan group <b>vlangrp1</b> vlan-list <b>91-95</b>	Creates a VLAN group with the given group name (vlangrp1) and adds all the VLANs listed in the command. The VLAN list ranges from 1 to 4096 and the recommended number of VLANs in a group is 32.
<b>Step 3</b>	<b>no vlan group</b> <i>WORD</i> <b>vlan-list</b> <i>vlan-ID</i> <b>Example:</b> Device(config)#no vlan group <b>vlangrp1</b> vlan-list <b>91-95</b>	Removes the VLAN group with the given group name (vlangrp1).
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)#end	Exits global configuration mode and returns to privileged EXEC mode. Alternatively, press <b>CTRL-Z</b> to exit global configuration mode.

## Adding a VLAN Group to a WLAN (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan</b> <i>WORD</i> <i>number</i>  <b>Example:</b> Device(config)# <code>wlan wlanname 512</code>	Enables the WLAN to map a VLAN group using an identifier. The WLAN identifier values range from 1 to 512.
<b>Step 3</b>	<b>client vlan</b> <i>WORD</i>  <b>Example:</b> Device(config-wlan)# <code>client vlan vlangrp1</code>	Maps the VLAN group to the WLAN by entering the VLAN identifier, VLAN group, or the VLAN name.
<b>Step 4</b>	<b>end</b>  <b>Example:</b> Device(config-wlan)# <code>end</code>	Exits global configuration mode and returns to privileged EXEC mode. Alternatively, press <b>CTRL-Z</b> to exit global configuration mode.

## Viewing the VLANs in a VLAN Group (CLI)

Command	Description
<code>show vlan group</code>	Displays the list of VLAN groups with name and the VLANs that are available.
<code>show vlan group group-name group_name</code>	Displays the specified VLAN group details.
<code>show wireless vlan group group_name</code>	Displays the specified wireless VLAN group details.

## Where to Go Next

After configuring VLAN groups, you can configure the following:

- VLANs
- VLAN Trunking Protocol (VTP)
- VLAN trunks
- Voice VLANs

# Additional References

## Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	<i>VLAN Command Reference (Catalyst 3850 Switches)</i> <i>Layer 2/3 Command Reference (Catalyst 3850 Switches)</i>
VLAN access-maps	<i>Security Configuration Guide (Catalyst 3850 Switches)</i> <i>Security Command Reference (Catalyst 3850 Switches)</i>
VLAN and Mobility Agents	<i>Mobility Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>
Cisco Flexible NetFlow	<i>Cisco Flexible NetFlow Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i> <i>Flexible Netflow Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>
IGMP Snooping	<i>IP Multicast Routing Command Reference (Catalyst 3850 Switches)</i> <i>IP Multicast Routing Configuration Guide (Catalyst 3850 Switches)</i>
IPv6	<i>IPv6 Configuration Guide (Catalyst 3850 Switches)</i> <i>IPv6 Command Reference (Catalyst 3850 Switches)</i>
SPAN	<i>Network Management Command Reference (Catalyst 3850 Switches)</i> <i>Network Management Configuration Guide (Catalyst 3850 Switches)</i>
Platform-independent configuration information	<i>Identity Based Networking Services Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>

## Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

## Standards and RFCs

Standard/RFC	Title
RFC 1573	Evolution of the Interfaces Group of MIB-II
RFC 1757	Remote Network Monitoring Management

Standard/RFC	Title
RFC 2021	SNMPv2 Management Information Base for the Transmission Control Protocol using SMIPv2

**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for VLAN Groups

Release	Modification
Cisco IOS XE 3.2E	This feature was introduced
Cisco IOS XE 3.3SE	VLAN GUI support.



## CHAPTER 157

# Configuring VLAN Trunks

- [Finding Feature Information, on page 2807](#)
- [Prerequisites for VLAN Trunks, on page 2807](#)
- [Restrictions for VLAN Trunks, on page 2808](#)
- [Information About VLAN Trunks, on page 2809](#)
- [How to Configure VLAN Trunks, on page 2811](#)
- [Where to Go Next, on page 2823](#)
- [Additional References, on page 2824](#)
- [Feature History and Information for VLAN Trunks, on page 2825](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for VLAN Trunks

The IEEE 802.1Q trunks impose these limitations on the trunking strategy for a network:

- In a network of Cisco devices connected through IEEE 802.1Q trunks, the devices maintain one spanning-tree instance for each VLAN allowed on the trunks. Non-Cisco devices might support one spanning-tree instance for all VLANs.

When you connect a Cisco device to a non-Cisco device through an IEEE 802.1Q trunk, the Cisco device combines the spanning-tree instance of the VLAN of the trunk with the spanning-tree instance of the non-Cisco IEEE 802.1Q device. However, spanning-tree information for each VLAN is maintained by Cisco devices separated by a cloud of non-Cisco IEEE 802.1Q devices. The non-Cisco IEEE 802.1Q cloud separating the Cisco devices is treated as a single trunk link between the devices.

- Make sure the native VLAN for an IEEE 802.1Q trunk is the same on both ends of the trunk link. If the native VLAN on one end of the trunk is different from the native VLAN on the other end, spanning-tree loops might result.
- Disabling spanning tree on the native VLAN of an IEEE 802.1Q trunk without disabling spanning tree on every VLAN in the network can potentially cause spanning-tree loops. We recommend that you leave spanning tree enabled on the native VLAN of an IEEE 802.1Q trunk or disable spanning tree on every VLAN in the network. Make sure your network is loop-free before disabling spanning tree.

## Restrictions for VLAN Trunks

The following are restrictions for VLAN trunks:

- A trunk port cannot be a secure port.
- Trunk ports can be grouped into EtherChannel port groups, but all trunks in the group must have the same configuration. When a group is first created, all ports follow the parameters set for the first port to be added to the group. If you change the configuration of one of these parameters, the device propagates the setting that you entered to all ports in the group:
  - Allowed-VLAN list.
  - STP port priority for each VLAN.
  - STP Port Fast setting.
  - Trunk status:
    - If one port in a port group ceases to be a trunk, all ports cease to be trunks.
- We recommend that you configure no more than 24 trunk ports in Per VLAN Spanning Tree (PVST) mode and no more than 40 trunk ports in Multiple Spanning Tree (MST) mode.
- If you try to enable IEEE 802.1x on a trunk port, an error message appears, and IEEE 802.1x is not enabled. If you try to change the mode of an IEEE 802.1x-enabled port to trunk, the port mode is not changed.
- A port in dynamic mode can negotiate with its neighbor to become a trunk port. If you try to enable IEEE 802.1x on a dynamic port, an error message appears, and IEEE 802.1x is not enabled. If you try to change the mode of an IEEE 802.1x-enabled port to dynamic, the port mode is not changed.
- Dynamic Trunking Protocol (DTP) is not supported on tunnel ports.
- The device does not support Layer 3 trunks; you cannot configure subinterfaces or use the **encapsulation** keyword on Layer 3 interfaces. The device does support Layer 2 trunks and Layer 3 VLAN interfaces, which provide equivalent capabilities.
- You cannot have a switch stack containing a mix of Catalyst 3850 and Catalyst 3650 switches.

# Information About VLAN Trunks

## Trunking Overview

A trunk is a point-to-point link between one or more Ethernet device interfaces and another networking device such as a router or a device. Ethernet trunks carry the traffic of multiple VLANs over a single link, and you can extend the VLANs across an entire network.

The following trunking encapsulations are available on all Ethernet interfaces:

- IEEE 802.1Q— Industry-standard trunking encapsulation.

## Trunking Modes

Ethernet trunk interfaces support different trunking modes. You can set an interface as trunking or nontrunking or to negotiate trunking with the neighboring interface. To autonegotiate trunking, the interfaces must be in the same VTP domain.

Trunk negotiation is managed by the Dynamic Trunking Protocol (DTP), which is a Point-to-Point Protocol (PPP). However, some internetworking devices might forward DTP frames improperly, which could cause misconfigurations.

### Related Topics

[Configuring a Trunk Port \(CLI\)](#), on page 2812

[Layer 2 Interface Modes](#), on page 2809

## Layer 2 Interface Modes

*Table 228: Layer 2 Interface Modes*

Mode	Function
<b>switchport mode access</b>	Puts the interface (access port) into permanent nontrunking mode and negotiates to convert the link into a nontrunk link. The interface becomes a nontrunk interface regardless of whether or not the neighboring interface is a trunk interface.
<b>switchport mode dynamic auto</b>	Makes the interface able to convert the link to a trunk link. The interface becomes a trunk interface if the neighboring interface is set to <b>trunk</b> or <b>desirable</b> mode. The default switchport mode for all Ethernet interfaces is <b>dynamic auto</b> .
<b>switchport mode dynamic desirable</b>	Makes the interface actively attempt to convert the link to a trunk link. The interface becomes a trunk interface if the neighboring interface is set to <b>trunk</b> , <b>desirable</b> , or <b>auto</b> mode.
<b>switchport mode trunk</b>	Puts the interface into permanent trunking mode and negotiates to convert the neighboring link into a trunk link. The interface becomes a trunk interface even if the neighboring interface is not a trunk interface.

Mode	Function
<b>switchport nonegotiate</b>	Prevents the interface from generating DTP frames. You can use this command only when the interface switchport mode is <b>access</b> or <b>trunk</b> . You must manually configure the neighboring interface as a trunk interface to establish a trunk link.

#### Related Topics

[Configuring a Trunk Port \(CLI\)](#), on page 2812

[Trunking Modes](#), on page 2809

## Allowed VLANs on a Trunk

By default, a trunk port sends traffic to and receives traffic from all VLANs. All VLAN IDs, 1 to 4094, are allowed on each trunk. However, you can remove VLANs from the allowed list, preventing traffic from those VLANs from passing over the trunk.

To reduce the risk of spanning-tree loops or storms, you can disable VLAN 1 on any individual VLAN trunk port by removing VLAN 1 from the allowed list. When you remove VLAN 1 from a trunk port, the interface continues to send and receive management traffic, for example, Cisco Discovery Protocol (CDP), Port Aggregation Protocol (PAgP), Link Aggregation Control Protocol (LACP), DTP, and VTP in VLAN 1.

If a trunk port with VLAN 1 disabled is converted to a nontrunk port, it is added to the access VLAN. If the access VLAN is set to 1, the port will be added to VLAN 1, regardless of the **switchport trunk allowed** setting. The same is true for any VLAN that has been disabled on the port.

A trunk port can become a member of a VLAN if the VLAN is enabled, if VTP knows of the VLAN, and if the VLAN is in the allowed list for the port. When VTP detects a newly enabled VLAN and the VLAN is in the allowed list for a trunk port, the trunk port automatically becomes a member of the enabled VLAN. When VTP detects a new VLAN and the VLAN is not in the allowed list for a trunk port, the trunk port does not become a member of the new VLAN.

#### Related Topics

[Defining the Allowed VLANs on a Trunk \(CLI\)](#), on page 2814

## Load Sharing on Trunk Ports

Load sharing divides the bandwidth supplied by parallel trunks connecting devices. To avoid loops, STP normally blocks all but one parallel link between devices. Using load sharing, you divide the traffic between the links according to which VLAN the traffic belongs.

You configure load sharing on trunk ports by using STP port priorities or STP path costs. For load sharing using STP port priorities, both load-sharing links must be connected to the same device. For load sharing using STP path costs, each load-sharing link can be connected to the same device or to two different devices.

## Network Load Sharing Using STP Priorities

When two ports on the same device form a loop, the device uses the STP port priority to decide which port is enabled and which port is in a blocking state. You can set the priorities on a parallel trunk port so that the port carries all the traffic for a given VLAN. The trunk port with the higher priority (lower values) for a VLAN is forwarding traffic for that VLAN. The trunk port with the lower priority (higher values) for the same VLAN remains in a blocking state for that VLAN. One trunk port sends or receives all traffic for the VLAN.



**Related Topics**

[Configuring Load Sharing Using STP Port Priorities \(CLI\)](#), on page 2818

## Network Load Sharing Using STP Path Cost

You can configure parallel trunks to share VLAN traffic by setting different path costs on a trunk and associating the path costs with different sets of VLANs, blocking different ports for different VLANs. The VLANs keep the traffic separate and maintain redundancy in the event of a lost link.

**Related Topics**

[Configuring Load Sharing Using STP Path Cost \(CLI\)](#), on page 2821

## Feature Interactions

Trunking interacts with other features in these ways:

- A trunk port cannot be a secure port.
- Trunk ports can be grouped into EtherChannel port groups, but all trunks in the group must have the same configuration. When a group is first created, all ports follow the parameters set for the first port to be added to the group. If you change the configuration of one of these parameters, the device propagates the setting that you entered to all ports in the group:
  - Allowed-VLAN list.
  - STP port priority for each VLAN.
  - STP Port Fast setting.
  - Trunk status:

If one port in a port group ceases to be a trunk, all ports cease to be trunks.

- We recommend that you configure no more than 24 trunk ports in Per VLAN Spanning Tree (PVST) mode and no more than 40 trunk ports in Multiple Spanning Tree (MST) mode.
- If you try to enable IEEE 802.1x on a trunk port, an error message appears, and IEEE 802.1x is not enabled. If you try to change the mode of an IEEE 802.1x-enabled port to trunk, the port mode is not changed.
- A port in dynamic mode can negotiate with its neighbor to become a trunk port. If you try to enable IEEE 802.1x on a dynamic port, an error message appears, and IEEE 802.1x is not enabled. If you try to change the mode of an IEEE 802.1x-enabled port to dynamic, the port mode is not changed.

## How to Configure VLAN Trunks

To avoid trunking misconfigurations, configure interfaces connected to devices that do not support DTP to not forward DTP frames, that is, to turn off DTP.

- If you do not intend to trunk across those links, use the **switchport mode access** interface configuration command to disable trunking.

- To enable trunking to a device that does not support DTP, use the **switchport mode trunk** and **switchport nonegotiate** interface configuration commands to cause the interface to become a trunk but to not generate DTP frames.

## Configuring an Ethernet Interface as a Trunk Port

### Configuring a Trunk Port (CLI)

Because trunk ports send and receive VTP advertisements, to use VTP you must ensure that at least one trunk port is configured on the device and that this trunk port is connected to the trunk port of a second device. Otherwise, the device cannot receive any VTP advertisements.

#### Before you begin

By default, an interface is in Layer 2 mode. The default mode for Layer 2 interfaces is **switchport mode dynamic auto**. If the neighboring interface supports trunking and is configured to allow trunking, the link is a Layer 2 trunk or, if the interface is in Layer 3 mode, it becomes a Layer 2 trunk when you enter the **switchport** interface configuration command.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device (config)# <b>interface gigabitethernet 1/0/2</b>	Specifies the port to be configured for trunking, and enters interface configuration mode.
<b>Step 4</b>	<b>switchport mode {dynamic {auto   desirable}   trunk}</b> <b>Example:</b> Device (config-if)# <b>switchport mode dynamic desirable</b>	Configures the interface as a Layer 2 trunk (required only if the interface is a Layer 2 access port or tunnel port or to specify the trunking mode). <ul style="list-style-type: none"> <li>• <b>dynamic auto</b>—Sets the interface to a trunk link if the neighboring interface is set to trunk or desirable mode. This is the default.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>dynamic desirable</b>—Sets the interface to a trunk link if the neighboring interface is set to trunk, desirable, or auto mode.</li> <li>• <b>trunk</b>—Sets the interface in permanent trunking mode and negotiate to convert the link to a trunk link even if the neighboring interface is not a trunk interface.</li> </ul>
<b>Step 5</b>	<b>switchport access vlan</b> <i>vlan-id</i> <b>Example:</b> <pre>Device(config-if)# switchport access vlan 200</pre>	(Optional) Specifies the default VLAN, which is used if the interface stops trunking.
<b>Step 6</b>	<b>switchport trunk native vlan</b> <i>vlan-id</i> <b>Example:</b> <pre>Device(config-if)# switchport trunk native vlan 200</pre>	Specifies the native VLAN for IEEE 802.1Q trunks.
<b>Step 7</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show interfaces</b> <i>interface-id</i> <b>switchport</b> <b>Example:</b> <pre>Device# show interfaces gigabitethernet 1/0/2 switchport</pre>	Displays the switch port configuration of the interface in the <i>Administrative Mode</i> and the <i>Administrative Trunking Encapsulation</i> fields of the display.
<b>Step 9</b>	<b>show interfaces</b> <i>interface-id</i> <b>trunk</b> <b>Example:</b> <pre>Device# show interfaces gigabitethernet 1/0/2 trunk</pre>	Displays the trunk configuration of the interface.
<b>Step 10</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Trunking Modes](#), on page 2809

[Layer 2 Interface Modes](#), on page 2809

**Defining the Allowed VLANs on a Trunk (CLI)**

VLAN 1 is the default VLAN on all trunk ports in all Cisco devices, and it has previously been a requirement that VLAN 1 always be enabled on every trunk link. You can use the VLAN 1 minimization feature to disable VLAN 1 on any individual VLAN trunk link so that no user traffic (including spanning-tree advertisements) is sent or received on VLAN 1.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/1</b>	Specifies the port to be configured, and enters interface configuration mode.
<b>Step 4</b>	<b>switchport mode trunk</b> <b>Example:</b> Device(config-if)# <b>switchport mode trunk</b>	Configures the interface as a VLAN trunk port.
<b>Step 5</b>	<b>switchport trunk allowed vlan { <i>word</i>   add   all   except   none   remove } <i>vlan-list</i></b> <b>Example:</b> Device(config-if)# <b>switchport trunk allowed vlan remove 2</b>	(Optional) Configures the list of VLANs allowed on the trunk.  The <i>vlan-list</i> parameter is either a single VLAN number from 1 to 4094 or a range of VLANs described by two VLAN numbers, the lower one first, separated by a hyphen. Do not enter any spaces between comma-separated VLAN parameters or in hyphen-specified ranges.  All VLANs are allowed by default.

	Command or Action	Purpose
<b>Step 6</b>	<b>end</b> <b>Example:</b>  Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 7</b>	<b>show interfaces interface-id switchport</b> <b>Example:</b>  Device# <b>show interfaces gigabitethernet 1/0/1 switchport</b>	Verifies your entries in the <i>Trunking VLANs Enabled</i> field of the display.
<b>Step 8</b>	<b>copy running-config startup-config</b> <b>Example:</b>  Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Allowed VLANs on a Trunk](#), on page 2810

**Changing the Pruning-Eligible List (CLI)**

The pruning-eligible list applies only to trunk ports. Each trunk port has its own eligibility list. VTP pruning must be enabled for this procedure to take effect.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b>  Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface interface-id</b> <b>Example:</b>  Device(config)# <b>interface</b>	Selects the trunk port for which VLANs should be pruned, and enters interface configuration mode.

	Command or Action	Purpose
	<code>gigabitethernet0/1</code>	
<b>Step 4</b>	<b>switchport trunk pruning vlan</b> { <b>add</b>   <b>except</b>   <b>none</b>   <b>remove</b> } <i>vlan-list</i> [, <i>vlan</i> [, <i>vlan</i> [,,,]]]	<p>Configures the list of VLANs allowed to be pruned from the trunk.</p> <p>For explanations about using the <b>add</b>, <b>except</b>, <b>none</b>, and <b>remove</b> keywords, see the command reference for this release.</p> <p>Separate non-consecutive VLAN IDs with a comma and no spaces; use a hyphen to designate a range of IDs. Valid IDs are 2 to 1001. Extended-range VLANs (VLAN IDs 1006 to 4094) cannot be pruned.</p> <p>VLANs that are pruning-ineligible receive flooded traffic.</p> <p>The default list of VLANs allowed to be pruned contains VLANs 2 to 1001.</p>
<b>Step 5</b>	<b>end</b> <b>Example:</b> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show interfaces</b> <i>interface-id</i> <b>switchport</b> <b>Example:</b> <pre>Device# show interfaces gigabitethernet 1/0/1 switchport</pre>	Verifies your entries in the <i>Pruning VLANs Enabled</i> field of the display.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

## Configuring the Native VLAN for Untagged Traffic (CLI)

A trunk port configured with IEEE 802.1Q tagging can receive both tagged and untagged traffic. By default, the device forwards untagged traffic in the native VLAN configured for the port. The native VLAN is VLAN 1 by default.

The native VLAN can be assigned any VLAN ID.

If a packet has a VLAN ID that is the same as the outgoing port native VLAN ID, the packet is sent untagged; otherwise, the device sends the packet with a tag.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <b>interface gigabitethernet 1/0/2</b>	Defines the interface that is configured as the IEEE 802.1Q trunk, and enters interface configuration mode.
<b>Step 4</b>	<b>switchport trunk native vlan <i>vlan-id</i></b> <b>Example:</b> Device(config-if)# <b>switchport trunk native vlan 12</b>	Configures the VLAN that is sending and receiving untagged traffic on the trunk port. For <i>vlan-id</i> , the range is 1 to 4094.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config-if)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show interfaces <i>interface-id</i> switchport</b> <b>Example:</b> Device# <b>show interfaces gigabitethernet 1/0/2 switchport</b>	Verifies your entries in the <i>Trunking Native Mode VLAN</i> field.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

# Configuring Trunk Ports for Load Sharing

## Configuring Load Sharing Using STP Port Priorities (CLI)

If your device is a member of a device stack, you must use the **spanning-tree [vlan *vlan-id*] cost *cost*** interface configuration command instead of the **spanning-tree [vlan *vlan-id*] port-priority *priority*** interface configuration command to select an interface to put in the forwarding state. Assign lower cost values to interfaces that you want selected first and higher cost values that you want selected last.

These steps describe how to configure a network with load sharing using STP port priorities.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode on Device A.
<b>Step 3</b>	<b>vtp domain <i>domain-name</i></b> <b>Example:</b> Device(config)# <b>vtp domain workdomain</b>	Configures a VTP administrative domain. The domain name can be 1 to 32 characters.
<b>Step 4</b>	<b>vtp mode server</b> <b>Example:</b> Device(config)# <b>vtp mode server</b>	Configures Device A as the VTP server.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show vtp status</b> <b>Example:</b> Device# <b>show vtp status</b>	Verifies the VTP configuration on both Device A and Device B. In the display, check the <i>VTP Operating Mode</i> and the <i>VTP Domain Name</i> fields.



	Command or Action	Purpose
<b>Step 7</b>	<b>show vlan</b> <b>Example:</b> Device# <code>show vlan</code>	Verifies that the VLANs exist in the database on Device A.
<b>Step 8</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 9</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device(config)# <code>interface gigabitethernet1/0/1</code>	Defines the interface to be configured as a trunk, and enters interface configuration mode.
<b>Step 10</b>	<b>switchport mode trunk</b> <b>Example:</b> Device(config-if)# <code>switchport mode trunk</code>	Configures the port as a trunk port.
<b>Step 11</b>	<b>end</b> <b>Example:</b> Device(config-if)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 12</b>	<b>show interfaces <i>interface-id</i> switchport</b> <b>Example:</b> Device# <code>show interfaces gigabitethernet 1/0/1 switchport</code>	Verifies the VLAN configuration.
<b>Step 13</b>	Repeat the above steps on Device A for a second port in the device or device stack.	
<b>Step 14</b>	Repeat the above steps on Device B to configure the trunk ports that connect to the trunk ports configured on Device A.	
<b>Step 15</b>	<b>show vlan</b> <b>Example:</b>	When the trunk links come up, VTP passes the VTP and VLAN information to Device B. This command verifies that Device B has learned the VLAN configuration.

	Command or Action	Purpose
	Device# <code>show vlan</code>	
<b>Step 16</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode on Device A.
<b>Step 17</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device (config)# <code>interface gigabitethernet 1/0/1</code>	Defines the interface to set the STP port priority, and enters interface configuration mode.
<b>Step 18</b>	<b>spanning-tree vlan <i>vlan-range</i> port-priority <i>priority-value</i></b> <b>Example:</b> Device (config-if)# <code>spanning-tree vlan 8-10 port-priority 16</code>	Assigns the port priority for the VLAN range specified. Enter a port priority value from 0 to 240. Port priority values increment by 16.
<b>Step 19</b>	<b>exit</b> <b>Example:</b> Device (config-if)# <code>exit</code>	Returns to global configuration mode.
<b>Step 20</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device (config)# <code>interface gigabitethernet 1/0/2</code>	Defines the interface to set the STP port priority, and enters interface configuration mode.
<b>Step 21</b>	<b>spanning-tree vlan <i>vlan-range</i> port-priority <i>priority-value</i></b> <b>Example:</b> Device (config-if)# <code>spanning-tree vlan 3-6 port-priority 16</code>	Assigns the port priority for the VLAN range specified. Enter a port priority value from 0 to 240. Port priority values increment by 16.
<b>Step 22</b>	<b>end</b> <b>Example:</b> Device (config-if)# <code>end</code>	Returns to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 23</b>	<b>show running-config</b> <b>Example:</b> Device# <code>show running-config</code>	Verifies your entries.
<b>Step 24</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <code>copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Network Load Sharing Using STP Priorities](#), on page 2810

**Configuring Load Sharing Using STP Path Cost (CLI)**

These steps describe how to configure a network with load sharing using STP path costs.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode on Device A.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> Device (config)# <code>interface gigabitethernet 1/0/1</code>	Defines the interface to be configured as a trunk, and enters interface configuration mode.
<b>Step 4</b>	<b>switchport mode trunk</b> <b>Example:</b> Device (config-if)# <code>switchport mode trunk</code>	Configures the port as a trunk port.

	Command or Action	Purpose
<b>Step 5</b>	<b>exit</b> <b>Example:</b>  Device (config-if) # <b>exit</b>	Returns to global configuration mode.
<b>Step 6</b>	Repeat Steps 2 through 4 on a second interface in Device A or in Device A stack.	
<b>Step 7</b>	<b>end</b> <b>Example:</b>  Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 8</b>	<b>show running-config</b> <b>Example:</b>  Device# <b>show running-config</b>	Verifies your entries. In the display, make sure that the interfaces are configured as trunk ports.
<b>Step 9</b>	<b>show vlan</b> <b>Example:</b>  Device# <b>show vlan</b>	When the trunk links come up, Device A receives the VTP information from the other devices. This command verifies that Device A has learned the VLAN configuration.
<b>Step 10</b>	<b>configure terminal</b> <b>Example:</b>  Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 11</b>	<b>interface interface-id</b> <b>Example:</b>  Device (config) # <b>interface gigabitethernet 1/0/1</b>	Defines the interface on which to set the STP cost, and enters interface configuration mode.
<b>Step 12</b>	<b>spanning-tree vlan vlan-range cost cost-value</b> <b>Example:</b>  Device (config-if) # <b>spanning-tree vlan 2-4 cost 30</b>	Sets the spanning-tree path cost to 30 for VLANs 2 through 4.
<b>Step 13</b>	<b>end</b> <b>Example:</b>	Returns to global configuration mode.

	Command or Action	Purpose
	<code>Device(config-if)# end</code>	
<b>Step 14</b>	Repeat Steps 9 through 13 on the other configured trunk interface on Device A, and set the spanning-tree path cost to 30 for VLANs 8, 9, and 10.	
<b>Step 15</b>	<b>exit</b> <b>Example:</b> <code>Device(config)# exit</code>	Returns to privileged EXEC mode.
<b>Step 16</b>	<b>show running-config</b> <b>Example:</b> <code>Device# show running-config</code>	Verifies your entries. In the display, verify that the path costs are set correctly for both trunk interfaces.
<b>Step 17</b>	<b>copy running-config startup-config</b> <b>Example:</b> <code>Device# copy running-config startup-config</code>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Network Load Sharing Using STP Path Cost](#), on page 2811

## Where to Go Next

After configuring VLAN trunks, you can configure the following:

- VLANs
- VLAN groups
- Voice VLANs

# Additional References

## Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	<i>VLAN Command Reference (Catalyst 3850 Switches)</i> <i>Layer 2/3 Command Reference (Catalyst 3850 Switches)</i> <i>Command Reference (Catalyst 9300 Series Switches)</i> <i>Command Reference (Catalyst 9500 Series Switches)</i>

## Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

## Standards and RFCs

Standard/RFC	Title
RFC 1573	Evolution of the Interfaces Group of MIB-II
RFC 1757	Remote Network Monitoring Management
RFC 2021	SNMPv2 Management Information Base for the Transmission Control Protocol using SMIV2

## MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for VLAN Trunks

Release	Modification
Cisco IOS XE 3.2SE	This command was introduced.







## CHAPTER 158

# Configuring Voice VLANs

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- [Finding Feature Information, on page 2827](#)
- [Prerequisites for Voice VLANs, on page 2827](#)
- [Restrictions for Voice VLANs, on page 2828](#)
- [Information About Voice VLAN, on page 2828](#)
- [How to Configure Voice VLAN, on page 2831](#)
- [Monitoring Voice VLAN, on page 2834](#)
- [Where to Go Next, on page 2834](#)
- [Additional References, on page 2835](#)
- [Feature History and Information for Voice VLAN, on page 2836](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Voice VLANs

The following are the prerequisites for voice VLANs:

- Voice VLAN configuration is only supported on device access ports; voice VLAN configuration is not supported on trunk ports.



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**Note** Trunk ports can carry any number of voice VLANs, similar to regular VLANs. The configuration of voice VLANs is not supported on trunk ports.

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- Before you enable voice VLAN, enable QoS on the device by entering the **trust device cisco-phone** interface configuration command. If you use the auto QoS feature, these settings are automatically configured.
- You must enable CDP on the device port connected to the Cisco IP Phone to send the configuration to the phone. (CDP is globally enabled by default on all device interfaces.)

## Restrictions for Voice VLANs

You cannot configure static secure MAC addresses in the voice VLAN.

## Information About Voice VLAN

### Voice VLANs

The voice VLAN feature enables access ports to carry IP voice traffic from an IP phone. When the device is connected to a Cisco 7960 IP Phone, the phone sends voice traffic with Layer 3 IP precedence and Layer 2 class of service (CoS) values, which are both set to 5 by default. Because the sound quality of an IP phone call can deteriorate if the data is unevenly sent, the device supports quality of service (QoS) based on IEEE 802.1p CoS. QoS uses classification and scheduling to send network traffic from the device in a predictable manner.

By default, the voice VLAN feature is disabled. When the feature is enabled, all untagged traffic is sent according to the default, CoS priority of the port. The CoS value is not trusted for IEEE 802.1Q or for IEEE 802.1p tagged traffic.

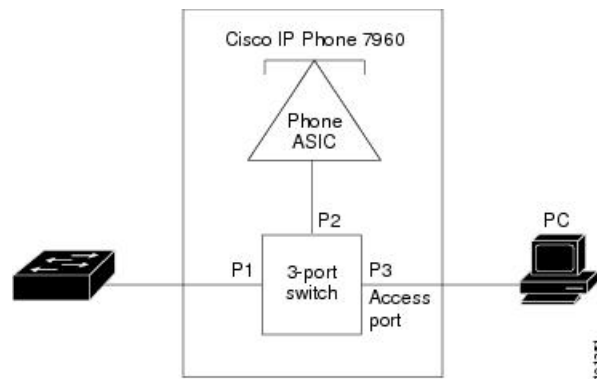
The Cisco 7960 IP Phone is a configurable device, and you can configure it to forward traffic with an IEEE 802.1p priority. You can configure the device to trust or override the traffic priority assigned by a Cisco IP Phone.

#### *Figure 149: Cisco 7960 IP Phone Connected to a Device*

This network configuration is one way to connect a Cisco 7960 IP Phone.

The Cisco IP Phone contains an integrated three-port 10/100 device. The ports provide dedicated connections to these devices:

- Port 1 connects to the device or other voice-over-IP (VoIP) device.
- Port 2 is an internal 10/100 interface that carries the IP phone traffic.
- Port 3 (access port) connects to a PC or other device.



## Cisco IP Phone Voice Traffic

You can configure an access port with an attached Cisco IP Phone to use one VLAN for voice traffic and another VLAN for data traffic from a device attached to the phone. You can configure access ports on the device to send Cisco Discovery Protocol (CDP) packets that instruct an attached phone to send voice traffic to the device in any of these ways:

- In the voice VLAN tagged with a Layer 2 CoS priority value
- In the access VLAN tagged with a Layer 2 CoS priority value
- In the access VLAN, untagged (no Layer 2 CoS priority value)



**Note** In all configurations, the voice traffic carries a Layer 3 IP precedence value (the default is 5 for voice traffic and 3 for voice control traffic).

### Related Topics

[Configuring Cisco IP Phone Voice Traffic \(CLI\)](#), on page 2831

[Monitoring Voice VLAN](#), on page 2834

## Cisco IP Phone Data Traffic

The device can also process tagged data traffic (traffic in IEEE 802.1Q or IEEE 802.1p frame types) from the device attached to the access port on the Cisco IP Phone. You can configure Layer 2 access ports on the device to send CDP packets that instruct the attached phone to configure the phone access port in one of these modes:

- In trusted mode, all traffic received through the access port on the Cisco IP Phone passes through the phone unchanged.
- In untrusted mode, all traffic in IEEE 802.1Q or IEEE 802.1p frames received through the access port on the Cisco IP Phone receive a configured Layer 2 CoS value. The default Layer 2 CoS value is 0. Untrusted mode is the default.




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**Note** Untagged traffic from the device attached to the Cisco IP Phone passes through the phone unchanged, regardless of the trust state of the access port on the phone.

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#### Related Topics

[Configuring the Priority of Incoming Data Frames \(CLI\)](#), on page 2833

[Monitoring Voice VLAN](#), on page 2834

## Voice VLAN Configuration Guidelines

- Because a Cisco 7960 IP Phone also supports a connection to a PC or other device, a port connecting the device to a Cisco IP Phone can carry mixed traffic. You can configure a port to decide how the Cisco IP Phone carries voice traffic and data traffic.
- The voice VLAN should be present and active on the device for the IP phone to correctly communicate on the voice VLAN. Use the **show vlan** privileged EXEC command to see if the VLAN is present (listed in the display). If the VLAN is not listed, create the voice VLAN.
- The Power over Ethernet (PoE) devices are capable of automatically providing power to Cisco pre-standard and IEEE 802.3af-compliant powered devices if they are not being powered by an AC power source.
- The Port Fast feature is automatically enabled when voice VLAN is configured. When you disable voice VLAN, the Port Fast feature is not automatically disabled.
- If the Cisco IP Phone and a device attached to the phone are in the same VLAN, they must be in the same IP subnet. These conditions indicate that they are in the same VLAN:
  - They both use IEEE 802.1p or untagged frames.
  - The Cisco IP Phone uses IEEE 802.1p frames, and the device uses untagged frames.
  - The Cisco IP Phone uses untagged frames, and the device uses IEEE 802.1p frames.
  - The Cisco IP Phone uses IEEE 802.1Q frames, and the voice VLAN is the same as the access VLAN.
- The Cisco IP Phone and a device attached to the phone cannot communicate if they are in the same VLAN and subnet but use different frame types because traffic in the same subnet is not routed (routing would eliminate the frame type difference).
- Voice VLAN ports can also be these port types:
  - Dynamic access port.
  - IEEE 802.1x authenticated port.




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**Note** If you enable IEEE 802.1x on an access port on which a voice VLAN is configured and to which a Cisco IP Phone is connected, the phone loses connectivity to the device for up to 30 seconds.

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- Protected port.
- A source or destination port for a SPAN or RSPAN session.

- Secure port.



**Note** When you enable port security on an interface that is also configured with a voice VLAN, you must set the maximum allowed secure addresses on the port to two plus the maximum number of secure addresses allowed on the access VLAN. When the port is connected to a Cisco IP Phone, the phone requires up to two MAC addresses. The phone address is learned on the voice VLAN and might also be learned on the access VLAN. Connecting a PC to the phone requires additional MAC addresses.

## How to Configure Voice VLAN

### Configuring Cisco IP Phone Voice Traffic (CLI)

You can configure a port connected to the Cisco IP Phone to send CDP packets to the phone to configure the way in which the phone sends voice traffic. The phone can carry voice traffic in IEEE 802.1Q frames for a specified voice VLAN with a Layer 2 CoS value. It can use IEEE 802.1p priority tagging to give voice traffic a higher priority and forward all voice traffic through the native (access) VLAN. The Cisco IP Phone can also send untagged voice traffic or use its own configuration to send voice traffic in the access VLAN. In all configurations, the voice traffic carries a Layer 3 IP precedence value (the default is 5).

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>interface <i>interface-id</i></b>  <b>Example:</b>  Device(config)# <code>interface gigabitethernet1/0/1</code>	Specifies the interface connected to the phone, and enters interface configuration mode.
<b>Step 3</b>	<b>trust device cisco-phone</b>  <b>Example:</b>  Device(config-if)# <code>trust device cisco-phone</code>	Configures the interface to trust incoming traffic packets for the Cisco IP phone.
<b>Step 4</b>	<b>switchport voice vlan {<i>vlan-id</i>   dot1p   none   untagged}</b>	Configures the voice VLAN.

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config-if) # <b>switchport voice vlan dot1p</b></pre>	<ul style="list-style-type: none"> <li>• <b>vlan-id</b>—Configures the phone to forward all voice traffic through the specified VLAN. By default, the Cisco IP Phone forwards the voice traffic with an IEEE 802.1Q priority of 5. Valid VLAN IDs are 1 to 4094.</li> <li>• <b>dot1p</b>—Configures the device to accept voice and data IEEE 802.1p priority frames tagged with VLAN ID 0 (the native VLAN). By default, the device drops all voice and data traffic tagged with VLAN 0. If configured for 802.1p the Cisco IP Phone forwards the traffic with an IEEE 802.1p priority of 5.</li> <li>• <b>none</b>—Allows the phone to use its own configuration to send untagged voice traffic.</li> <li>• <b>untagged</b>—Configures the phone to send untagged voice traffic.</li> </ul>
<b>Step 5</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-if) # <b>end</b></pre>	Returns to privileged EXEC mode.
<b>Step 6</b>	<p>Use one of the following:</p> <ul style="list-style-type: none"> <li>• <b>show interfaces <i>interface-id</i> switchport</b></li> <li>• <b>show running-config interface <i>interface-id</i></b></li> </ul> <p><b>Example:</b></p> <pre>Device# <b>show interfaces gigabitethernet1/0/1 switchport</b></pre> <p>or</p> <pre>Device# <b>show running-config interface gigabitethernet1/0/1</b></pre>	Verifies your voice VLAN entries or your QoS and voice VLAN entries.
<b>Step 7</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# <b>copy running-config startup-config</b></pre>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Cisco IP Phone Voice Traffic](#), on page 2829

[Monitoring Voice VLAN](#), on page 2834

**Configuring the Priority of Incoming Data Frames (CLI)**

You can connect a PC or other data device to a Cisco IP Phone port. To process tagged data traffic (in IEEE 802.1Q or IEEE 802.1p frames), you can configure the device to send CDP packets to instruct the phone how to send data packets from the device attached to the access port on the Cisco IP Phone. The PC can generate packets with an assigned CoS value. You can configure the phone to not change (trust) or to override (not trust) the priority of frames arriving on the phone port from connected devices.

Follow these steps to set the priority of data traffic received from the non-voice port on the Cisco IP Phone:

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> <pre>Device(config)# interface gigabitethernet1/0/1</pre>	Specifies the interface connected to the Cisco IP Phone, and enters interface configuration mode.
<b>Step 4</b>	<b>switchport priority extend {<i>cos value</i>   trust}</b> <b>Example:</b> <pre>Device(config-if)# switchport priority extend trust</pre>	Sets the priority of data traffic received from the Cisco IP Phone access port: <ul style="list-style-type: none"> <li>• <b>cos value</b>—Configures the phone to override the priority received from the PC or the attached device with the specified CoS value. The value is a number from 0 to 7, with 7 as the highest priority. The default priority is <b>cos 0</b>.</li> <li>• <b>trust</b>—Configures the phone access port to trust the priority received from the PC or the attached device.</li> </ul>

	Command or Action	Purpose
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device (config-if) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show interfaces <i>interface-id</i> switchport</b> <b>Example:</b> Device# <b>show interfaces</b> <b>gigabitethernet1/0/1 switchport</b>	Verifies your entries.
<b>Step 7</b>	<b>copy running-config startup-config</b> <b>Example:</b> Device# <b>copy running-config</b> <b>startup-config</b>	(Optional) Saves your entries in the configuration file.

**Related Topics**

- [Cisco IP Phone Data Traffic](#), on page 2829
- [Monitoring Voice VLAN](#), on page 2834

## Monitoring Voice VLAN

To display voice VLAN configuration for an interface, use the **show interfaces *interface-id* switchport** privileged EXEC command.

**Related Topics**

- [Configuring Cisco IP Phone Voice Traffic \(CLI\)](#), on page 2831
- [Cisco IP Phone Voice Traffic](#), on page 2829
- [Configuring the Priority of Incoming Data Frames \(CLI\)](#), on page 2833
- [Cisco IP Phone Data Traffic](#), on page 2829

## Where to Go Next

After configuring voice VLANs, you can configure the following:

- VLANs
- VLAN groups
- VLAN Trunking
- VTP



# Additional References

## Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	<i>VLAN Command Reference (Catalyst 3850 Switches)</i> <i>Layer 2/3 Command Reference (Catalyst 3850 Switches)</i> <i>Command Reference (Catalyst 9500 Series Switches)</i> <i>Command Reference (Catalyst 9300 Series Switches)</i>

## Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

## Standards and RFCs

Standard/RFC	Title
RFC 1573	Evolution of the Interfaces Group of MIB-II
RFC 1757	Remote Network Monitoring Management
RFC 2021	SNMPv2 Management Information Base for the Transmission Control Protocol using SMIV2

## MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

**Feature History and Information for Voice VLAN**

Release	Modification
Cisco IOS XE 3.2SE	This feature was introduced.



## CHAPTER 159

# Configuring Private VLANs

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- [Finding Feature Information, on page 2837](#)
- [Prerequisites for Private VLANs, on page 2837](#)
- [Restrictions for Private VLANs, on page 2837](#)
- [Information About Private VLANs, on page 2838](#)
- [How to Configure Private VLANs, on page 2847](#)
- [Monitoring Private VLANs, on page 2856](#)
- [Configuration Examples for Private VLANs, on page 2856](#)
- [Where to Go Next, on page 2858](#)
- [Additional References, on page 2859](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Private VLANs

Private vlans are supported in transparent mode for VTP 1, 2 and 3. Private VLANs are also supported on server mode with VTP 3.

When configuring private VLANs on the device, always use the default Switch Database Management (SDM) template to balance system resources between unicast routes and Layer 2 entries. If another SDM template is configured, use the **sdm prefer default** global configuration command to set the default template.

## Restrictions for Private VLANs

- Do not configure fallback bridging on devices with private VLANs.

- Do not configure a remote SPAN (RSPAN) VLAN as a private-VLAN primary or secondary VLAN.
- Do not configure private-VLAN ports on interfaces configured for these other features:
  - Dynamic-access port VLAN membership
  - Dynamic Trunking Protocol (DTP)
  - IPv6 Security Group (SG)
  - Port Aggregation Protocol (PAgP)
  - Link Aggregation Control Protocol (LACP)
  - Multicast VLAN Registration (MVR)
  - Voice VLAN
  - Web Cache Communication Protocol (WCCP)
- You can configure IEEE 802.1x port-based authentication on a private-VLAN port, but do not configure 802.1x with port security, voice VLAN, or per-user ACL on private-VLAN ports.
- A private-VLAN host or promiscuous port cannot be a SPAN destination port. If you configure a SPAN destination port as a private-VLAN port, the port becomes inactive.
- If you configure a static MAC address on a promiscuous port in the primary VLAN, you need not add the same static address to all associated secondary VLANs. Similarly, if you configure a static MAC address on a host port in a secondary VLAN, you need not add the same static MAC address to the associated primary VLAN. Also, when you delete a static MAC address from a private-VLAN port, you do not have to remove all instances of the configured MAC address from the private VLAN.



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**Note** Dynamic MAC addresses learned in Secondary VLAN of a private VLAN are replicated to the Primary VLANs. All mac entries are learnt on secondary VLANs, even if the traffic ingresses from primary VLAN. If a mac-address is dynamically learnt in the primary VLAN it will not get replicated in the associated secondary VLANs.

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- Configure Layer 3 VLAN interfaces (SVIs) only for primary VLANs.

## Information About Private VLANs

### Private VLAN Domains

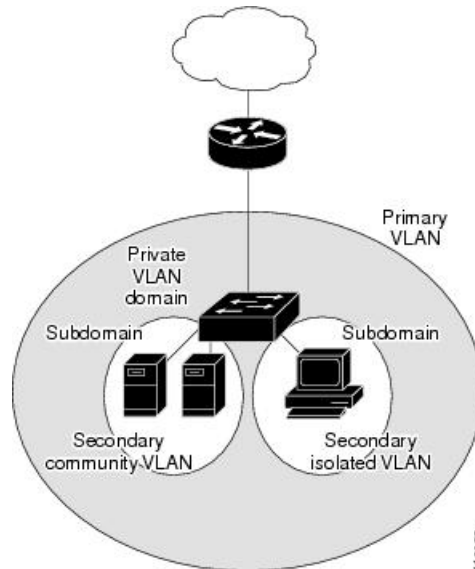
The private VLAN feature addresses two problems that service providers face when using VLANs:

- When running the IP Base or IP Services image, the device supports up to 4094 active VLANs. If a service provider assigns one VLAN per customer, this limits the numbers of customers the service provider can support.

- To enable IP routing, each VLAN is assigned a subnet address space or a block of addresses, which can result in wasting the unused IP addresses, and cause IP address management problems.

**Figure 150: Private VLAN Domain**

Using private VLANs addresses the scalability problem and provides IP address management benefits for service providers and Layer 2 security for customers. Private VLANs partition a regular VLAN domain into subdomains. A subdomain is represented by a pair of VLANs: a *primary* VLAN and a *secondary* VLAN. A private VLAN can have multiple VLAN pairs, one pair for each subdomain. All VLAN pairs in a private VLAN share the same primary VLAN. The secondary VLAN ID differentiates one subdomain from another.



## Secondary VLANs

There are two types of secondary VLANs:

- Isolated VLANs—Ports within an isolated VLAN cannot communicate with each other at the Layer 2 level.
- Community VLANs—Ports within a community VLAN can communicate with each other but cannot communicate with ports in other communities at the Layer 2 level.

### Related Topics

[Mapping Secondary VLANs to a Primary VLAN Layer 3 VLAN Interface](#), on page 2854

[Example: Mapping Secondary VLANs to a Primary VLAN Interface](#), on page 2858

## Private VLANs Ports

Private VLANs provide Layer 2 isolation between ports within the same private VLAN. Private VLAN ports are access ports that are one of these types:

- Promiscuous—A promiscuous port belongs to the primary VLAN and can communicate with all interfaces, including the community and isolated host ports that belong to the secondary VLANs associated with the primary VLAN.

- **Isolated**—An isolated port is a host port that belongs to an isolated secondary VLAN. It has complete Layer 2 separation from other ports within the same private VLAN, except for the promiscuous ports. Private VLANs block all traffic to isolated ports except traffic from promiscuous ports. Traffic received from an isolated port is forwarded only to promiscuous ports.
- **Community**—A community port is a host port that belongs to a community secondary VLAN. Community ports communicate with other ports in the same community VLAN and with promiscuous ports. These interfaces are isolated at Layer 2 from all other interfaces in other communities and from isolated ports within their private VLAN.




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**Note** Trunk ports carry traffic from regular VLANs and also from primary, isolated, and community VLANs.

---

Primary and secondary VLANs have these characteristics:

- **Primary VLAN**—A private VLAN has only one primary VLAN. Every port in a private VLAN is a member of the primary VLAN. The primary VLAN carries unidirectional traffic downstream from the promiscuous ports to the (isolated and community) host ports and to other promiscuous ports.
- **Isolated VLAN**—A private VLAN has only one isolated VLAN. An isolated VLAN is a secondary VLAN that carries unidirectional traffic upstream from the hosts toward the promiscuous ports and the gateway.
- **Community VLAN**—A community VLAN is a secondary VLAN that carries upstream traffic from the community ports to the promiscuous port gateways and to other host ports in the same community. You can configure multiple community VLANs in a private VLAN.

A promiscuous port can serve only one primary VLAN, one isolated VLAN, and multiple community VLANs. Layer 3 gateways are typically connected to the device through a promiscuous port. With a promiscuous port, you can connect a wide range of devices as access points to a private VLAN. For example, you can use a promiscuous port to monitor or back up all the private VLAN servers from an administration workstation.

#### Related Topics

[Configuring a Layer 2 Interface as a Private VLAN Host Port](#), on page 2851

[Configuring a Layer 2 Interface as a Private VLAN Promiscuous Port](#), on page 2852

[Example: Configuring an Interface as a Host Port](#), on page 2857

[Example: Configuring an Interface as a Private VLAN Promiscuous Port](#), on page 2857

## Private VLANs in Networks

In a switched environment, you can assign an individual private VLAN and associated IP subnet to each individual or common group of end stations. The end stations need to communicate only with a default gateway to communicate outside the private VLAN.

You can use private VLANs to control access to end stations in these ways:

- Configure selected interfaces connected to end stations as isolated ports to prevent any communication at Layer 2. For example, if the end stations are servers, this configuration prevents Layer 2 communication between the servers.
- Configure interfaces connected to default gateways and selected end stations (for example, backup servers) as promiscuous ports to allow all end stations access to a default gateway.

You can extend private VLANs across multiple devices by trunking the primary, isolated, and community VLANs to other devices that support private VLANs. To maintain the security of your private VLAN configuration and to avoid other use of the VLANs configured as private VLANs, configure private VLANs on all intermediate devices, including devices that have no private VLAN ports.

## IP Addressing Scheme with Private VLANs

Assigning a separate VLAN to each customer creates an inefficient IP addressing scheme:

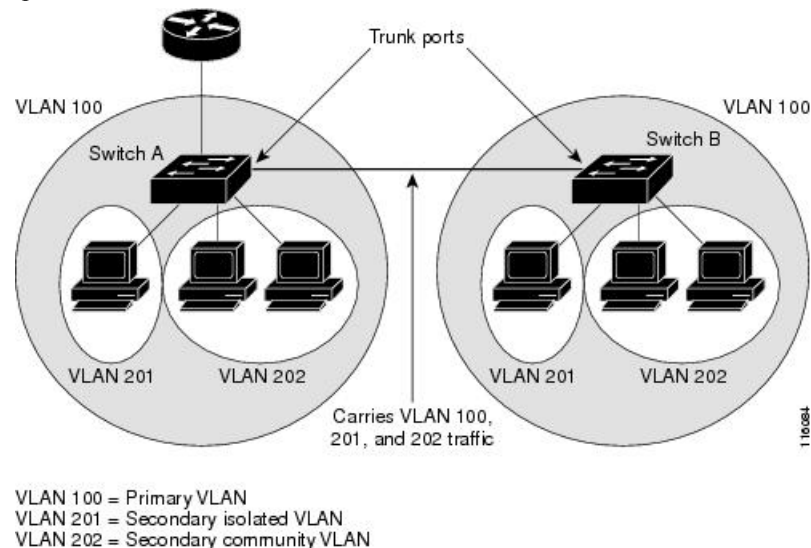
- Assigning a block of addresses to a customer VLAN can result in unused IP addresses.
- If the number of devices in the VLAN increases, the number of assigned address might not be large enough to accommodate them.

These problems are reduced by using private VLANs, where all members in the private VLAN share a common address space, which is allocated to the primary VLAN. Hosts are connected to secondary VLANs, and the DHCP server assigns them IP addresses from the block of addresses allocated to the primary VLAN. Subsequent IP addresses can be assigned to customer devices in different secondary VLANs, but in the same primary VLAN. When new devices are added, the DHCP server assigns them the next available address from a large pool of subnet addresses.

## Private VLANs Across Multiple Devices

**Figure 151: Private VLANs Across Switches**

As with regular VLANs, private VLANs can span multiple devices. A trunk port carries the primary VLAN and secondary VLANs to a neighboring device. The trunk port treats the private VLAN as any other VLAN. A feature of private VLANs across multiple devices is that traffic from an isolated port in Device A does not reach an isolated port on Device B.



Private VLANs are supported in transparent mode for VTP 1, 2 and 3. Private vlan is also supported on server mode for VTP 3. If we have a server client setup using VTP 3, private vlans configured on the server should be reflected on the client.

# Private-VLAN Interaction with Other Features

## Private VLANs and Unicast, Broadcast, and Multicast Traffic

In regular VLANs, devices in the same VLAN can communicate with each other at the Layer 2 level, but devices connected to interfaces in different VLANs must communicate at the Layer 3 level. In private VLANs, the promiscuous ports are members of the primary VLAN, while the host ports belong to secondary VLANs. Because the secondary VLAN is associated to the primary VLAN, members of these VLANs can communicate with each other at the Layer 2 level.

In a regular VLAN, broadcasts are forwarded to all ports in that VLAN. Private VLAN broadcast forwarding depends on the port sending the broadcast:

- An isolated port sends a broadcast only to the promiscuous ports or trunk ports.
- A community port sends a broadcast to all promiscuous ports, trunk ports, and ports in the same community VLAN.
- A promiscuous port sends a broadcast to all ports in the private VLAN (other promiscuous ports, trunk ports, isolated ports, and community ports).

Multicast traffic is routed or bridged across private VLAN boundaries and within a single community VLAN. Multicast traffic is not forwarded between ports in the same isolated VLAN or between ports in different secondary VLANs.

Private VLAN multicast forwarding supports the following:

- Sender can be outside the VLAN and the Receivers can be inside the VLAN domain.
- Sender can be inside the VLAN and the Receivers can be outside the VLAN domain.
- Sender and Receiver can both be in the same community vlan.

## Private VLANs and SVIs

In a Layer 3 device, a device virtual interface (SVI) represents the Layer 3 interface of a VLAN. Layer 3 devices communicate with a private VLAN only through the primary VLAN and not through secondary VLANs. Configure Layer 3 VLAN interfaces (SVIs) only for primary VLANs. You cannot configure Layer 3 VLAN interfaces for secondary VLANs. SVIs for secondary VLANs are inactive while the VLAN is configured as a secondary VLAN.

- If you try to configure a VLAN with an active SVI as a secondary VLAN, the configuration is not allowed until you disable the SVI.
- If you try to create an SVI on a VLAN that is configured as a secondary VLAN and the secondary VLAN is already mapped at Layer 3, the SVI is not created, and an error is returned. If the SVI is not mapped at Layer 3, the SVI is created, but it is automatically shut down.

When the primary VLAN is associated with and mapped to the secondary VLAN, any configuration on the primary VLAN is propagated to the secondary VLAN SVIs. For example, if you assign an IP subnet to the primary VLAN SVI, this subnet is the IP subnet address of the entire private VLAN.



## Private VLANs and Device Stacks

Private VLANs can operate within the device stack, and private-VLAN ports can reside on different stack members. However, the following changes to the stack can impact private-VLAN operation:

- If a stack contains only one private-VLAN promiscuous port and the stack member that contains that port is removed from the stack, host ports in that private VLAN lose connectivity outside the private VLAN.
- If a stack master stack that contains the only private-VLAN promiscuous port in the stack fails or leaves the stack and a new stack master is elected, host ports in a private VLAN that had its promiscuous port on the old stack master lose connectivity outside of the private VLAN.
- If two stacks merge, private VLANs on the winning stack are not affected, but private-VLAN configuration on the losing device is lost when that device reboots.

## Private VLAN with Dynamic Mac Address

The Mac addresses learnt in the secondary VLAN are replicated to the primary VLAN and not vice-versa. This saves the hardware l2 cam space. The primary VLAN is always used for forwarding lookups in both directions.

Dynamic MAC addresses learned in Primary VLAN of a private VLAN are then, if required, replicated in the secondary VLANs. For example, if a mac-address is dynamically received on the secondary VLAN, it will be learnt as part of primary VLAN. In case of isolated VLANs, a blocked entry for the same mac will be added to secondary VLAN in the mac address table. So, mac learnt on host ports in secondary domain are installed as blocked type entries. All mac entries are learnt on secondary VLANs, even if the traffic ingresses from primary VLAN.

However, if a mac-address is dynamically learnt in the primary VLAN it will not get replicated in the associated secondary VLANs.

## Private VLAN with Static Mac Address

Users are not required to replicate the Static Mac Address CLI for private VLAN hosts as compare to legacy model.

Example:

- In the legacy model, if the user configures a static mac address, they need to add same mac static mac-address in the associated VLAN too. For example, if mac-address A is user configured on port 1/0/1 in VLAN 101, where VLAN 101 is a secondary VLAN and VLAN 100 is a primary VLAN, then the user has to configure

```
mac-address static A vlan 101 interface G1/0/1
mac-address static A vlan 100 interface G1/0/1
```

- In this device, the user does not need to replicate the mac address to the associated VLAN. For the above example, user has to configure only

```
mac-address static A vlan 101 interface G1/0/1
```

## Private VLAN Interaction with VACL/QOS

Private VLANs are bidirectional in case of this device, as compared to “Unidirectional” in other platforms.

After layer-2 forward lookup, proper egress VLAN mapping happens and all the egress VLAN based feature processing happens in the egress VLAN context.

When a frame in Layer-2 is forwarded within a private VLAN, the VLAN map is applied at the ingress side and at the egress side. When a frame is routed from inside a private VLAN to an external port, the private-VLAN map is applied at the ingress side. Similarly, when the frame is routed from an external port to a Private VLAN, the private-VLAN is applied at the egress side. This is applicable to both bridged and routed traffic.

#### **Bridging:**

- For upstream traffic from secondary VLAN to primary VLAN, the MAP of the secondary VLAN is applied on the ingress side and the MAP of the primary VLAN is applied on the egress side.
- For downstream traffic from primary VLAN to secondary VLAN, the MAP of the primary VLAN is applied in the ingress direction and the MAP of the secondary VLAN is applied in the egress direction.

#### **Routing**

If we have two private VLAN domains - PV1 (sec1, prim1) and PV2 (sec2, prim2). For frames routed from PV1 to PV2:

- The MAP of sec1 and L3 ACL of prim1 is applied in the ingress port.
- The MAP of sec2 and L3 ACL of prim2 is applied in the egress port.

For packets going upstream or downstream from isolated host port to promiscuous port, the isolated VLAN's VACL is applied in the ingress direction and primary VLAN's VACL is applied in the egress direction. This allows user to configure different VACL for different secondary VLAN in a same primary VLAN domain.




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**Note** 2-way community VLAN is now not required as the private VLANs on this device are always bi-directional.

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## **Private VLANs and HA Support**

PVLAN will work seamlessly with High Availability (HA) feature. The Private VLAN existing on the master before switchover should be the same after switchover (new master should have similar PVLAN configuration both on IOS side and FED side as that of the old master).

## **Private-VLAN Configuration Guidelines**

### **Default Private-VLAN Configurations**

No private VLANs are configured.

### **Secondary and Primary VLAN Configuration**

Follow these guidelines when configuring private VLANs:

- Private VLANs are supported in transparent mode for VTP 1, 2 and 3. If the device is running VTP version 1 or 2, you must set VTP to transparent mode. After you configure a private VLAN, you should not change the VTP mode to client or server. VTP version 3 supports private VLANs in all modes.

- With VTP version 1 or 2, after you have configured private VLANs, use the **copy running-config startup-config** privileged EXEC command to save the VTP transparent mode configuration and private-VLAN configuration in the device startup configuration file. Otherwise, if the device resets, it defaults to VTP server mode, which does not support private VLANs. VTP version 3 does support private VLANs.
- VTP version 1 and 2 do not propagate private-VLAN configuration. You must configure private VLANs on each device where you want private-VLAN ports unless the devices are running VTP version 3, as VTP3 propagate private vlans.
- You cannot configure VLAN 1 or VLANs 1002 to 1005 as primary or secondary VLANs. Extended VLANs (VLAN IDs 1006 to 4094) can belong to private VLANs.
- A primary VLAN can have one isolated VLAN and multiple community VLANs associated with it. An isolated or community VLAN can have only one primary VLAN associated with it.
- Although a private VLAN contains more than one VLAN, only one Spanning Tree Protocol (STP) instance runs for the entire private VLAN. When a secondary VLAN is associated with the primary VLAN, the STP parameters of the primary VLAN are propagated to the secondary VLAN.
- When copying a PVLAN configuration from a tftp server and applying it on a running-config, the PVLAN association will not be formed. You will need to check and ensure that the primary VLAN is associated to all the secondary VLANs.

You can also use **configure replace flash:config\_file force** instead of **copy flash:config\_file running-config**.

- You can enable DHCP snooping on private VLANs. When you enable DHCP snooping on the primary VLAN, it is propagated to the secondary VLANs. If you configure DHCP on a secondary VLAN, the configuration does not take effect if the primary VLAN is already configured.
- When you enable IP source guard on private-VLAN ports, you must enable DHCP snooping on the primary VLAN.
- We recommend that you prune the private VLANs from the trunks on devices that carry no traffic in the private VLANs.
- You can apply different quality of service (QoS) configurations to primary, isolated, and community VLANs.
- Note the following considerations for sticky ARP:
  - Sticky ARP entries are those learned on SVIs and Layer 3 interfaces. These entries do not age out.
  - The **ip sticky-arp** global configuration command is supported only on SVIs belonging to private VLANs.
  - The **ip sticky-arp** interface configuration command is only supported on:
    - Layer 3 interfaces
    - SVIs belonging to normal VLANs
    - SVIs belonging to private VLANs

For more information about using the **ip sticky-arp global** configuration and the **ip sticky-arp interface** configuration commands, see the command reference for this release.

- You can configure VLAN maps on primary and secondary VLANs. However, we recommend that you configure the same VLAN maps on private-VLAN primary and secondary VLANs.
- PVLANS are bidirectional. They can be applied at both the ingress and egress sides.

When a frame in Layer-2 is forwarded within a private VLAN, the VLAN map is applied at the ingress side and at the egress side. When a frame is routed from inside a private VLAN to an external port, the private-VLAN map is applied at the ingress side. Similarly, when the frame is routed from an external port to a Private VLAN, the private-VLAN is applied at the egress side.

#### Bridging

- For upstream traffic from secondary VLAN to primary VLAN, the MAP of the secondary VLAN is applied on the ingress side and the MAP of the primary VLAN is applied on the egress side.
- For downstream traffic from primary VLAN to secondary VLAN, the MAP of the primary VLAN is applied in the ingress direction and the MAP of the secondary VLAN is applied in the egress direction.

#### Routing

If we have two private VLAN domains - PV1 (sec1, prim1) and PV2 (sec2, prim2). For frames routed from PV1 to PV2:

- The MAP of sec1 and L3 ACL of prim1 is applied in the ingress port .
- The MAP of sec1 and L3 ACL of prim2 is applied in the egress port.
- For packets going upstream or downstream from isolated host port to promiscuous port, the isolated VLAN's VACL is applied in the ingress direction and primary VLAN'S VACL is applied in the egress direction. This allows user to configure different VACL for different secondary VLAN in a same primary VLAN domain.

To filter out specific IP traffic for a private VLAN, you should apply the VLAN map to both the primary and secondary VLANs.

- You can apply router ACLs only on the primary-VLAN SVIs. The ACL is applied to both primary and secondary VLAN Layer 3 traffic.
- Although private VLANs provide host isolation at Layer 2, hosts can communicate with each other at Layer 3.
- Private VLANs support these Switched Port Analyzer (SPAN) features:
  - You can configure a private-VLAN port as a SPAN source port.
  - You can use VLAN-based SPAN (VSPAN) on primary, isolated, and community VLANs or use SPAN on only one VLAN to separately monitor egress or ingress traffic.

## Private VLAN Port Configuration

Follow these guidelines when configuring private VLAN ports:

- Use only the private VLAN configuration commands to assign ports to primary, isolated, or community VLANs. Layer 2 access ports assigned to the VLANs that you configure as primary, isolated, or community VLANs are inactive while the VLAN is part of the private VLAN configuration. Layer 2 trunk interfaces remain in the STP forwarding state.

- Do not configure ports that belong to a PAgP or LACP EtherChannel as private VLAN ports. While a port is part of the private VLAN configuration, any EtherChannel configuration for it is inactive.
- Enable Port Fast and BPDU guard on isolated and community host ports to prevent STP loops due to misconfigurations and to speed up STP convergence. When enabled, STP applies the BPDU guard feature to all Port Fast-configured Layer 2 LAN ports. Do not enable Port Fast and BPDU guard on promiscuous ports.
- If you delete a VLAN used in the private VLAN configuration, the private VLAN ports associated with the VLAN become inactive.
- Private VLAN ports can be on different network devices if the devices are trunk-connected and the primary and secondary VLANs have not been removed from the trunk.

# How to Configure Private VLANs

## Configuring Private VLANs

To configure a private VLAN, perform these steps:



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**Note** Private vlans are supported in transparent mode for VTP 1, 2 and 3. Private VLANs are also supported on server mode with VTP 3.

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### Procedure

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- Step 1** Set VTP mode to **transparent**.
- Note** Note: For VTP3, you can set mode to either server or transparent mode.
- Step 2** Create the primary and secondary VLANs and associate them.
- See the [Configuring and Associating VLANs in a Private VLAN, on page 2848](#)
- Note** If the VLAN is not created already, the private-VLAN configuration process creates it.
- Step 3** Configure interfaces to be isolated or community host ports, and assign VLAN membership to the host port.
- See the [Configuring a Layer 2 Interface as a Private VLAN Host Port, on page 2851](#)
- Step 4** Configure interfaces as promiscuous ports, and map the promiscuous ports to the primary-secondary VLAN pair.
- See the [Configuring a Layer 2 Interface as a Private VLAN Promiscuous Port, on page 2852](#)
- Step 5** If inter-VLAN routing will be used, configure the primary SVI, and map secondary VLANs to the primary.
- See the [Mapping Secondary VLANs to a Primary VLAN Layer 3 VLAN Interface, on page 2854](#)

**Step 6** Verify private-VLAN configuration.

## Configuring and Associating VLANs in a Private VLAN

The **private-vlan** commands do not take effect until you exit VLAN configuration mode.

To configure and associate VLANs in a Private VLAN, perform these steps:

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>vtp mode transparent</b> <b>Example:</b> Device(config)# <b>vtp mode transparent</b>	Sets VTP mode to transparent (disable VTP). <b>Note</b> For VTP3, you can set mode to either server or transparent mode
<b>Step 4</b>	<b>vlan <i>vlan-id</i></b> <b>Example:</b> Device(config)# <b>vlan 20</b>	Enters VLAN configuration mode and designates or creates a VLAN that will be the primary VLAN. The VLAN ID range is 2 to 1001 and 1006 to 4094.
<b>Step 5</b>	<b>private-vlan primary</b> <b>Example:</b> Device(config-vlan)# <b>private-vlan primary</b>	Designates the VLAN as the primary VLAN.
<b>Step 6</b>	<b>exit</b> <b>Example:</b> Device(config-vlan)# <b>exit</b>	Returns to global configuration mode.

	Command or Action	Purpose
<b>Step 7</b>	<b>vlan <i>vlan-id</i></b> <b>Example:</b> Device (config) # <b>vlan 501</b>	(Optional) Enters VLAN configuration mode and designates or creates a VLAN that will be an isolated VLAN. The VLAN ID range is 2 to 1001 and 1006 to 4094.
<b>Step 8</b>	<b>private-vlan isolated</b> <b>Example:</b> Device (config-vlan) # <b>private-vlan isolated</b>	Designates the VLAN as an isolated VLAN.
<b>Step 9</b>	<b>exit</b> <b>Example:</b> Device (config-vlan) # <b>exit</b>	Returns to global configuration mode.
<b>Step 10</b>	<b>vlan <i>vlan-id</i></b> <b>Example:</b> Device (config) # <b>vlan 502</b>	(Optional) Enters VLAN configuration mode and designates or creates a VLAN that will be a community VLAN. The VLAN ID range is 2 to 1001 and 1006 to 4094.
<b>Step 11</b>	<b>private-vlan community</b> <b>Example:</b> Device (config-vlan) # <b>private-vlan community</b>	Designates the VLAN as a community VLAN.
<b>Step 12</b>	<b>exit</b> <b>Example:</b> Device (config-vlan) # <b>exit</b>	Returns to global configuration mode.
<b>Step 13</b>	<b>vlan <i>vlan-id</i></b> <b>Example:</b> Device (config) # <b>vlan 503</b>	(Optional) Enters VLAN configuration mode and designates or creates a VLAN that will be a community VLAN. The VLAN ID range is 2 to 1001 and 1006 to 4094.
<b>Step 14</b>	<b>private-vlan community</b> <b>Example:</b> Device (config-vlan) # <b>private-vlan</b>	Designates the VLAN as a community VLAN.

	Command or Action	Purpose
	<code>community</code>	
<b>Step 15</b>	<b>exit</b> <b>Example:</b> Device (config-vlan) # <b>exit</b>	Returns to global configuration mode.
<b>Step 16</b>	<b>vlan <i>vlan-id</i></b> <b>Example:</b> Device (config) # <b>vlan 20</b>	Enters VLAN configuration mode for the primary VLAN designated in Step 4.
<b>Step 17</b>	<b>private-vlan association [add   remove] <i>secondary_vlan_list</i></b> <b>Example:</b> Device (config-vlan) # <b>private-vlan association 501-503</b>	Associates the secondary VLANs with the primary VLAN. It can be a single private-VLAN ID or a hyphenated range of private-VLAN IDs. <ul style="list-style-type: none"> <li>• The <i>secondary_vlan_list</i> parameter cannot contain spaces. It can contain multiple comma-separated items. Each item can be a single private-VLAN ID or a hyphenated range of private-VLAN IDs.</li> <li>• The <i>secondary_vlan_list</i> parameter can contain multiple community VLAN IDs but only one isolated VLAN ID.</li> <li>• Enter a <i>secondary_vlan_list</i>, or use the <b>add</b> keyword with a <i>secondary_vlan_list</i> to associate secondary VLANs with a primary VLAN.</li> <li>• Use the <b>remove</b> keyword with a <i>secondary_vlan_list</i> to clear the association between secondary VLANs and a primary VLAN.</li> <li>• The command does not take effect until you exit VLAN configuration mode.</li> </ul>
<b>Step 18</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode.
<b>Step 19</b>	<b>show vlan private-vlan [type] or show interfaces status</b>	Verifies the configuration.



	Command or Action	Purpose
	<b>Example:</b>  Device# <code>show vlan private-vlan</code>	
<b>Step 20</b>	<b>copy running-config startup config</b>  <b>Example:</b>  Device# <code>copy running-config startup-config</code>	Saves your entries in the device startup configuration file.

## Configuring a Layer 2 Interface as a Private VLAN Host Port

Follow these steps to configure a Layer 2 interface as a private-VLAN host port and to associate it with primary and secondary VLANs:



**Note** Isolated and community VLANs are both secondary VLANs.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b>  Device> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b>  Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b>  <b>Example:</b>  Device(config)# <code>interface gigabitethernet1/0/22</code>	Enters interface configuration mode for the Layer 2 interface to be configured.
<b>Step 4</b>	<b>switchport mode private-vlan host</b>  <b>Example:</b>  Device(config-if)# <code>switchport mode</code>	Configures the Layer 2 port as a private-VLAN host port.

	Command or Action	Purpose
	<code>private-vlan host</code>	
<b>Step 5</b>	<p><b>switchport private-vlan host-association</b> <i>primary_vlan_id secondary_vlan_id</i></p> <p><b>Example:</b></p> <pre>Device(config-if)# switchport private-vlan host-association 20 501</pre>	<p>Associates the Layer 2 port with a private VLAN.</p> <p><b>Note</b> This is a required step to associate the PVLAN to a Layer 2 interface.</p>
<b>Step 6</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode.
<b>Step 7</b>	<p><b>show interfaces</b> [<i>interface-id</i>] <b>switchport</b></p> <p><b>Example:</b></p> <pre>Device# show interfaces gigabitethernet1/0/22 switchport</pre>	Verifies the configuration.
<b>Step 8</b>	<p><b>copy running-config startup-config</b></p> <p><b>Example:</b></p> <pre>Device# copy running-config startup-config</pre>	(Optional) Saves your entries in the configuration file.

**Related Topics**

[Private VLANs Ports](#), on page 2839

[Example: Configuring an Interface as a Host Port](#), on page 2857

[Example: Configuring an Interface as a Private VLAN Promiscuous Port](#), on page 2857

## Configuring a Layer 2 Interface as a Private VLAN Promiscuous Port

Follow these steps to configure a Layer 2 interface as a private VLAN promiscuous port and map it to primary and secondary VLANs:



**Note** Isolated and community VLANs are both secondary VLANs.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> <pre>Device&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b>	<b>interface <i>interface-id</i></b> <b>Example:</b> <pre>Device(config)# interface gigabitethernet1/0/2</pre>	Enters interface configuration mode for the Layer 2 interface to be configured.
<b>Step 4</b>	<b>switchport mode private-vlan promiscuous</b> <b>Example:</b> <pre>Device(config-if)# switchport mode private-vlan promiscuous</pre>	Configures the Layer 2 port as a private VLAN promiscuous port.
<b>Step 5</b>	<b>switchport private-vlan mapping</b> <i>primary_vlan_id</i> { <b>add</b>   <b>remove</b> } <i>secondary_vlan_list</i> <b>Example:</b> <pre>Device(config-if)# switchport private-vlan mapping 20 add 501-503</pre>	Maps the private VLAN promiscuous port to a primary VLAN and to selected secondary VLANs. <ul style="list-style-type: none"> <li>• The <i>secondary_vlan_list</i> parameter cannot contain spaces. It can contain multiple comma-separated items. Each item can be a single private VLAN ID or a hyphenated range of private VLAN IDs.</li> <li>• Enter a <i>secondary_vlan_list</i>, or use the <b>add</b> keyword with a <i>secondary_vlan_list</i> to map the secondary VLANs to the private VLAN promiscuous port.</li> <li>• Use the <b>remove</b> keyword with a <i>secondary_vlan_list</i> to clear the mapping between secondary VLANs and the private VLAN promiscuous port.</li> </ul>
<b>Step 6</b>	<b>end</b> <b>Example:</b>	Returns to privileged EXEC mode.

	Command or Action	Purpose
	Device(config)# <b>end</b>	
<b>Step 7</b>	<b>show interfaces [interface-id] switchport</b> <b>Example:</b> Device# <b>show interfaces gigabitethernet1/0/2 switchport</b>	Verifies the configuration.
<b>Step 8</b>	<b>copy running-config startup config</b> <b>Example:</b> Device# <b>copy running-config startup-config</b>	Saves your entries in the device startup configuration file.

**Related Topics**

[Private VLANs Ports](#), on page 2839

[Example: Configuring an Interface as a Host Port](#), on page 2857

[Example: Configuring an Interface as a Private VLAN Promiscuous Port](#), on page 2857

## Mapping Secondary VLANs to a Primary VLAN Layer 3 VLAN Interface

If the private VLAN will be used for inter-VLAN routing, you configure an SVI for the primary VLAN and map secondary VLANs to the SVI.



**Note** Isolated and community VLANs are both secondary VLANs.

Follow these steps to map secondary VLANs to the SVI of a primary VLAN to allow Layer 3 switching of private VLAN traffic:

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b>	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 3</b>	<b>interface vlan</b> <i>primary_vlan_id</i> <b>Example:</b> Device(config)# <code>interface vlan 20</code>	Enters interface configuration mode for the primary VLAN, and configures the VLAN as an SVI. The VLAN ID range is 2 to 1001 and 1006 to 4094.
<b>Step 4</b>	<b>private-vlan mapping</b> [ <code>add</code>   <code>remove</code> ] <i>secondary_vlan_list</i> <b>Example:</b> Device(config-if)# <code>private-vlan mapping 501-503</code>	Maps the secondary VLANs to the Layer 3 VLAN interface of a primary VLAN to allow Layer 3 switching of private VLAN ingress traffic.  <b>Note</b> The <b>private-vlan mapping</b> interface configuration command only affects private VLAN traffic that is Layer 3 switched. <ul style="list-style-type: none"> <li>• The <i>secondary_vlan_list</i> parameter cannot contain spaces. It can contain multiple comma-separated items. Each item can be a single private-VLAN ID or a hyphenated range of private-VLAN IDs.</li> <li>• Enter a <i>secondary_vlan_list</i>, or use the <b>add</b> keyword with a <i>secondary_vlan_list</i> to map the secondary VLANs to a primary VLAN.</li> <li>• Use the <b>remove</b> keyword with a <i>secondary_vlan_list</i> to clear the mapping between secondary VLANs and a primary VLAN.</li> </ul>
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode.
<b>Step 6</b>	<b>show interface private-vlan mapping</b> <b>Example:</b> Device# <code>show interfaces private-vlan mapping</code>	Verifies the configuration.
<b>Step 7</b>	<b>copy running-config startup config</b> <b>Example:</b>	Saves your entries in the device startup configuration file.

	Command or Action	Purpose
	Device# <code>copy running-config startup-config</code>	

### Related Topics

[VTP Domain](#), on page 2761

[Secondary VLANs](#), on page 2839

[Example: Mapping Secondary VLANs to a Primary VLAN Interface](#), on page 2858

## Monitoring Private VLANs

The following table displays the commands used to monitor private VLANs.

*Table 229: Private VLAN Monitoring Commands*

Command	Purpose
<code>show interfaces status</code>	Displays the status of interfaces, including the VLANs to which they belongs.
<code>show vlan private-vlan [type]</code>	Displays the private VLAN information for the Device or Device stack.
<code>show interface switchport</code>	Displays private VLAN configuration on interfaces.
<code>show interface private-vlan mapping</code>	Displays information about the private VLAN mapping for VLAN SVIs.

## Configuration Examples for Private VLANs

### Example: Configuring and Associating VLANs in a Private VLAN

This example shows how to configure VLAN 20 as a primary VLAN, VLAN 501 as an isolated VLAN, and VLANs 502 and 503 as community VLANs, to associate them in a private VLAN, and to verify the configuration:

```
Device# configure terminal
Device(config)# vlan 20
Device(config-vlan)# private-vlan primary
Device(config-vlan)# exit
Device(config)# vlan 501
Device(config-vlan)# private-vlan isolated
Device(config-vlan)# exit
Device(config)# vlan 502
Device(config-vlan)# private-vlan community
Device(config-vlan)# exit
Device(config)# vlan 503
```

```

Device(config-vlan)# private-vlan community
Device(config-vlan)# exit
Device(config)# vlan 20
Device(config-vlan)# private-vlan association 501-503
Device(config-vlan)# end
Device# show vlan private-vlan
Primary   Secondary   Type
-----
20        501         isolated
20        502         community
20        503         community

```

## Example: Configuring an Interface as a Host Port

This example shows how to configure an interface as a private VLAN host port, associate it with a private VLAN pair, and verify the configuration:

```

Device# configure terminal
Device(config)# interface gigabitethernet1/0/22
Device(config-if)# switchport mode private-vlan host
Device(config-if)# switchport private-vlan host-association 20 501
Device(config-if)# end
Device# show interfaces gigabitethernet1/0/22 switchport
Name: Gi1/0/22
Switchport: Enabled
Administrative Mode: private-vlan host
Operational Mode: private-vlan host
Administrative Trunking Encapsulation: negotiate
Operational Trunking Encapsulation: native
Negotiation of Trunking: Off
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
Administrative Native VLAN tagging: enabled
Voice VLAN: none
Administrative private-vlan host-association: 20 501
Administrative private-vlan mapping: none
Administrative private-vlan trunk native VLAN: none
Administrative private-vlan trunk Native VLAN tagging: enabled
Administrative private-vlan trunk encapsulation: dot1q
Administrative private-vlan trunk normal VLANs: none
Administrative private-vlan trunk private VLANs: none
Operational private-vlan:
20 501

<output truncated>

```

### Related Topics

[Private VLANs Ports](#), on page 2839

[Configuring a Layer 2 Interface as a Private VLAN Host Port](#), on page 2851

[Configuring a Layer 2 Interface as a Private VLAN Promiscuous Port](#), on page 2852

## Example: Configuring an Interface as a Private VLAN Promiscuous Port

This example shows how to configure an interface as a private VLAN promiscuous port and map it to a private VLAN. The interface is a member of primary VLAN 20 and secondary VLANs 501 to 503 are mapped to it.

```
Device# configure terminal
Device(config)# interface gigabitethernet1/0/2
Device(config-if)# switchport mode private-vlan promiscuous
Device(config-if)# switchport private-vlan mapping 20 add 501-503
Device(config-if)# end
```

Use the **show vlan private-vlan** or the **show interface status** privileged EXEC command to display primary and secondary VLANs and private-VLAN ports on the Device.

### Related Topics

[Private VLANs Ports](#), on page 2839

[Configuring a Layer 2 Interface as a Private VLAN Host Port](#), on page 2851

[Configuring a Layer 2 Interface as a Private VLAN Promiscuous Port](#), on page 2852

## Example: Mapping Secondary VLANs to a Primary VLAN Interface

This example shows how to map the interfaces for VLANs 501 and 502 to primary VLAN 10, which permits routing of secondary VLAN ingress traffic from private VLANs 501 and 502:

```
Device# configure terminal
Device(config)# interface vlan 20
Device(config-if)# private-vlan mapping 501-503
Device(config-if)# end
Device# show interfaces private-vlan mapping
Interface Secondary VLAN Type
-----
vlan20      501          isolated
vlan20      502          community
vlan20      503          community
```

### Related Topics

[VTP Domain](#), on page 2761

[Secondary VLANs](#), on page 2839

[Mapping Secondary VLANs to a Primary VLAN Layer 3 VLAN Interface](#), on page 2854

## Example: Monitoring Private VLANs

This example shows output from the **show vlan private-vlan** command:

```
Device# show vlan private-vlan
Primary Secondary Type Ports
-----
20      501      isolated   Gi1/0/22, Gi1/0/2
20      502      community  Gi1/0/2
20      503      community  Gi1/0/2
```

## Where to Go Next

You can configure the following:



- VTP
- VLANs
- VLAN trunking
- Voice VLANs

## Additional References

### Related Documents

Related Topic	Document Title
CLI commands	LAN Switching Command Reference, Cisco IOS Release

### Standards and RFCs

Standard/RFC	Title
RFC 1573	
RFC 1757	
RFC 2021	

**MIBs**

MIB	MIBs Link
<p>All the supported MIBs for this release.</p> <ul style="list-style-type: none"> <li>• BRIDGE-MIB (RFC1493)</li> <li>• CISCO-BRIDGE-EXT-MIB</li> <li>• CISCO-CDP-MIB</li> <li>• CISCO-PAGP-MIB</li> <li>• CISCO-PRIVATE-VLAN-MIB</li> <li>• CISCO-LAG-MIB</li> <li>• CISCO-L2L3-INTERFACE-CONFIG-MIB</li> <li>• CISCO-MAC-NOTIFICATION-MIB</li> <li>• CISCO-STP-EXTENSIONS-MIB</li> <li>• CISCO-VLAN-IFTABLE-RELATIONSHIP-MIB</li> <li>• CISCO-VLAN-MEMBERSHIP-MIB</li> <li>• CISCO-VTP-MIB</li> <li>• IEEE8023-LAG-MIB</li> <li>• IF-MIB (RFC 1573)</li> <li>• RMON-MIB (RFC 1757)</li> <li>• RMON2-MIB (RFC 2021)</li> </ul>	<p>To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:</p> <p><a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a></p>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<p><a href="http://www.cisco.com/support">http://www.cisco.com/support</a></p>



## PART **XXII**

### **WLAN**

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- [Configuring Remote-LAN, on page 2881](#)
- [DHCP for WLANs, on page 2889](#)
- [WLAN Security, on page 2907](#)
- [Setting Client Count Per WLAN, on page 2915](#)
- [802.11w, on page 2921](#)
- [Configuring Wi-Fi Direct Client Policy, on page 2929](#)
- [Configuring 802.11r BSS Fast Transition, on page 2935](#)
- [Assisted Roaming, on page 2947](#)
- [Configuring Access Point Groups, on page 2953](#)





## CHAPTER 160

# WLANs

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- [Finding Feature Information, on page 2863](#)
- [Information About WLANs, on page 2863](#)
- [Prerequisites for WLANs, on page 2867](#)
- [Restrictions for WLANs, on page 2867](#)
- [How to Configure WLANs, on page 2870](#)
- [Monitoring WLAN Properties \(CLI\), on page 2878](#)
- [Where to Go Next, on page 2878](#)
- [Additional References, on page 2878](#)
- [Feature Information for WLANs, on page 2879](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About WLANs

This feature enables you to control up to 64 WLANs for lightweight access points. Each WLAN has a separate WLAN ID, a separate profile name, and a WLAN SSID. All devices publish up to 16 WLANs to each connected access point, but you can create up to the maximum number of WLANs supported and then selectively publish these WLANs (using access point groups) to different access points to better manage your wireless network.

You can configure WLANs with different SSIDs or with the same SSID. An SSID identifies the specific wireless network that you want the device to access.

## Band Selection

Band selection enables client radios that are capable of dual-band (2.4 and 5-GHz) operations to move to a less congested 5-GHz access point. The 2.4-GHz band is often congested. Clients on this band typically experience interference from Bluetooth devices, microwave ovens, and cordless phones as well as co-channel interference from other access points because of the 802.11b/g limit of 3 nonoverlapping channels. To prevent these sources of interference and improve overall network performance, configure band selection on the device.

### Related Topics

[Configuring Advanced WLAN Properties \(CLI\)](#), on page 2875

[Prerequisites for WLANs](#), on page 2867

[Restrictions for WLANs](#), on page 2867

## Off-Channel Scanning Deferral

A lightweight access point, in normal operational conditions, periodically goes off channel and scans another channel. This is in order to perform RRM operations such as the following:

- Transmitting and receiving NDP packets with other APs.
- Detecting rogue APs and clients.
- Measuring noise and interference.

During the off channel period, which normally is about 70 milliseconds, the AP is unable to transmit or receive data on its serving channel. Therefore, there is a slight impact on its performance and some client transmissions might be dropped.

While the AP is sending and receiving important data, it is possible to configure off-channel scanning deferral so that the AP does not go off channel and its normal operation is not impacted. You can configure off-channel scanning deferral on a per-WLAN basis, per WMM UP class basis, with a specified time threshold in milliseconds. If the AP sends or receives, on a particular WLAN, a data frame marked with the given UP class within the specified threshold, the AP defers its next RRM off-channel scan. For example, by default, off-channel scanning deferral is enabled for UP classes 4, 5, and 6, with a time threshold of 100 milliseconds. Therefore, when RRM is about to perform an off-channel scan, a data frame marked with UP 4, 5, or 6 is received within the last 100 milliseconds, RRM defers going off-channel. If a voice call, which is sending and receiving audio samples, marked as UP 6, every 20 milliseconds is active, then the AP radio does not go off channel.

Off-channel scanning deferral does come with a tradeoff. Off-channel scanning can impact throughput by 2 percent or more, depending on the configuration, traffic patterns, and so on. Throughput can be slightly improved if you enable off-channel scanning deferral for all traffic classes and increase the time threshold. However, by not going off-channel, RRM can fail to identify AP neighbors and rogues, resulting in negative impact to security, DCA, TPC, and 802.11k messages.

We recommend that you do not change the default off-channel scanning deferral settings.

## DTIM Period

In the 802.11 networks, lightweight access points broadcast a beacon at regular intervals, which coincides with the Delivery Traffic Indication Map (DTIM). After the access point broadcasts the beacon, it transmits

any buffered broadcast and multicast frames based on the value set for the DTIM period. This feature allows power-saving clients to wake up at the appropriate time if they are expecting broadcast or multicast data.

Typically, the DTIM value is set to 1 (to transmit broadcast and multicast frames after every beacon) or 2 (to transmit after every other beacon). For instance, if the beacon period of the 802.11 network is 100 ms and the DTIM value is set to 1, the access point transmits buffered broadcast and multicast frames 10 times per second. If the beacon period is 100 ms and the DTIM value is set to 2, the access point transmits buffered broadcast and multicast frames 5 times per second. Either of these settings are suitable for applications, including Voice Over IP (VoIP), that expect frequent broadcast and multicast frames.

However, the DTIM value can be set as high as 255 (to transmit broadcast and multicast frames after every 255th beacon) if all 802.11 clients have power save enabled. Because the clients have to listen only when the DTIM period is reached, they can be set to listen for broadcasts and multicasts less frequently which results in a longer battery life. For example, if the beacon period is 100 ms and you set the DTIM value to 100, the access point transmits buffered broadcast and multicast frames once every 10 seconds. This rate allows the power-saving clients to sleep longer before they have to wake up and listen for broadcasts and multicasts, which results in a longer battery life.

**Note**

A beacon period, which is specified in milliseconds on the device, is converted internally by the software to 802.11 Time Units (TUs), where 1 TU = 1.024 milliseconds. On Cisco's 802.11n access points, this value is rounded to the nearest multiple of 17 TUs. For example, a configured beacon period of 100 ms results in an actual beacon period of 104 ms.

Many applications cannot tolerate a long time between broadcast and multicast messages, which results in poor protocol and application performance. We recommend that you set a low DTIM value for 802.11 networks that support such clients.

## Session Timeouts

You can configure a WLAN with a session timeout. The session timeout is the maximum time for a client session to remain active before requiring reauthorization.

## Cisco Client Extensions

The Cisco Client Extensions (CCX) software is licensed to manufacturers and vendors of third-party client devices. The CCX code resident on these clients enables them to communicate wirelessly with Cisco access points and to support Cisco features that other client devices do not, including those features that are related to increased security, enhanced performance, fast roaming, and power management.

- The software supports CCX versions 1 through 5, which enables devices and their access points to communicate wirelessly with third-party client devices that support CCX. CCX support is enabled automatically for every WLAN on the device and cannot be disabled. However, you can configure Aironet information elements (IEs).
- If Aironet IE support is enabled, the access point sends an Aironet IE 0x85 (which contains the access point name, load, number of associated clients, and so on) in the beacon and probe responses of this WLAN, and the device sends Aironet IEs 0x85 and 0x95 (which contains the management IP address of the device and the IP address of the access point) in the reassociation response if it receives Aironet IE 0x85 in the reassociation request.

**Related Topics**

- [Configuring Advanced WLAN Properties \(CLI\)](#), on page 2875
- [Prerequisites for WLANs](#), on page 2867
- [Restrictions for WLANs](#), on page 2867

## Peer-to-Peer Blocking

Peer-to-peer blocking is applied to individual WLANs, and each client inherits the peer-to-peer blocking setting of the WLAN to which it is associated. Peer-to-Peer enables you to have more control over how traffic is directed. For example, you can choose to have traffic bridged locally within the device, dropped by the device, or forwarded to the upstream VLAN.

Peer-to-peer blocking is supported for clients that are associated with the local switching WLAN.

**Related Topics**

- [Configuring Advanced WLAN Properties \(CLI\)](#), on page 2875
- [Prerequisites for WLANs](#), on page 2867
- [Restrictions for WLANs](#), on page 2867

## Diagnostic Channel

You can choose a diagnostic channel to troubleshoot why the client is having communication problems with a WLAN. You can test the client and access points to identify the difficulties that the client is experiencing and allow corrective measures to be taken to make the client operational on the network. You can use the device GUI or CLI to enable the diagnostic channel, and you can use the device CLI to run the diagnostic tests.

**Note**

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We recommend that you enable the diagnostic channel feature only for nonanchored SSIDs that use the management interface. CCX Diagnostic feature has been tested only with clients having Cisco ADU card

---

## Per-WLAN Radius Source Support

The device sources RADIUS traffic from the IP address of its management interface unless the configured RADIUS server exists on a VLAN accessible via one of the device Dynamic interfaces. If a RADIUS server is reachable via a device Dynamic interface, RADIUS requests to this specific RADIUS server will be sourced from the controller via the corresponding Dynamic interface.

By default, RADIUS packets sourced from the device will set the NAS-IP-Address attribute to that of the management interface's IP Address, regardless of the packet's source IP Address (Management or Dynamic, depending on topology).

When you enable per-WLAN RADIUS source support (Radius Server Overwrite interface) the NAS-IP-Address attribute is overwritten by the device to reflect the sourced interface. Also, RADIUS attributes are modified accordingly to match the identity. This feature virtualizes the device on the per-WLAN RADIUS traffic, where each WLAN can have a separate layer 3 identity. This feature is useful in deployments that integrate with ACS Network Access Restrictions and Network Access Profiles.



To filter WLANs, use the `callStationID` that is set by RFC 3580 to be in the `APMAC:SSID` format. You can also extend the filtering on the authentication server to be on a per-WLAN source interface by using the `NAS-IP-Address` attribute.

You can combine per-WLAN RADIUS source support with the normal RADIUS traffic source and some WLANs that use the management interface and others using the per-WLAN dynamic interface as the address source.

## Prerequisites for WLANs

- You can associate up to 16 WLANs with each access point group and assign specific access points to each group. Each access point advertises only the enabled WLANs that belong to its access point group. The access point (AP) does not advertise disabled WLANs in its access point group or WLANs that belong to another group.
- We recommend that you assign one set of VLANs for WLANs and a different set of VLANs for management interfaces to ensure that devices properly route VLAN traffic.

### Related Topics

- [Creating WLANs \(CLI\)](#), on page 2870
- [Configuring General WLAN Properties \(CLI\)](#), on page 2873
- [Deleting WLANs \(CLI\)](#), on page 2871
- [Configuring Advanced WLAN Properties \(CLI\)](#), on page 2875
- [Band Selection](#), on page 2864
- [DTIM Period](#)
- [Session Timeout](#)
- [Cisco Client Extensions](#), on page 2865
- [Peer-to-Peer Blocking](#), on page 2866
- [Diagnostic Channel](#)
- [Client Count Per WLAN](#)
- [Enabling WLANs \(CLI\)](#), on page 2872
- [Disabling WLANs \(CLI\)](#), on page 2873

## Restrictions for WLANs

- When you change the WLAN profile name, then FlexConnect APs (using AP-specific VLAN mapping) will become WLAN-specific. If FlexConnect Groups are properly configured, the VLAN mapping will become Group-specific.
- Do not enable IEEE 802.1X Fast Transition on Flex Local Authentication enabled WLAN, as client association is not supported with Fast Transition 802.1X key management.
- Peer-to-peer blocking does not apply to multicast traffic.
- You can configure a maximum up to of 2000 clients.
- The WLAN name and SSID can have up to 32 characters.
- Special characters are not supported for the WLAN name.

- WLAN name cannot be a keyword; for example, if you try to create a WLAN with the name as 's' by entering the **wlan s** command, it results in shutting down all WLANs because 's' is used as a keyword for shutdown.
- You cannot map a WLAN to VLAN0, and you cannot map VLANs 1002 to 1006.
- Dual stack clients with a static-IPv4 address is not supported.
- When creating a WLAN with the same SSID, you must create a unique profile name for each WLAN.
- When multiple WLANs with the same SSID get assigned to the same AP radio, you must have a unique Layer 2 security policy so that clients can safely select between them.
- When WLAN is local switching, associate the client to local-switching WLAN where AVC is enabled. Send some traffic from client, when you check the AVC stats after 90 sec. Cisco WLC shows stats under top-apps but does not show under client. There is timer issue so for the first slot Cisco WLC might not show stats for the clients. Earlier, only 1 sec stats for a client is seen if the timers at AP and at WLC are off by 89 seconds. Now, clearing of the stats is after 180 seconds so stats from 91 seconds to 179 seconds for a client is seen. This is done because two copies of the stats per client cannot be kept due to memory constraint in Cisco 5508 WLC.
- RADIUS Server Overwrite interface per wlan feature is not supported. However, you can achieve the same using the following configuration:
  - Configure a RADIUS Authentication Server
  - Configure a RADIUS Authentication Server Group
  - Create 802.1x WLAN
  - Configure Wireless Profile Policy and Attach it to the VLAN

#### Configure a RADIUS Authentication Server

- Device (config)# **radius server** *server-name*
- Device (config-radius-server)# **address ipv4** *address* **auth-port** *auth\_port\_number* **acct-port** *acct\_port\_number*
- Device (config-radius-server)# **key** *key*

#### Configure a RADIUS Authentication Server Group

- Device(config)# **aaa group server radius** *server-name*
- Device(config)# **server name** *server-name*
- Device(config)# **ip radius source-interface** *vlan* *vlan-name*
- Device(config)# **aaa authentication dot1x** *dot1x\_name* **group** *server-name*

#### Create 802.1x WLAN

- Device(config)# **wlan** *wlan-name id ssid*
- Device(config-wlan)# **security dot1x authentication-list** *list-name*
- Device(config-wlan)# **no shutdown**

### Configure Wireless Profile Policy and Attach it to VLAN

- Device(config)# **wireless profile policy** *profile-name*
- Device(config-wireless-policy)# **vlan** *vlan-name*
- Device(config-wireless-policy)# **no shutdown**

A sample configuration on the Cisco Wireless Controller is given below:

```
radius server RAD_EXT_3

address ipv4 9.2.62.56 auth-port 1812 acct-port 1813

key cisco

aaa group server radius AAA_EXT_3
server name RAD_EXT_3
ip radius source-interface vlan 50

aaa authentication dot1x test_ext group AAA_EXT_3

wlan test_wpa2_dot1x 2 test_wpa2_dot1x
security dot1x authentication-list test_ext
no shutdown

wireless profile policy pp-1
vlan 50
no shutdown

radius server RAD_EXT_3

address ipv4 9.2.62.56 auth-port 1812 acct-port 1813

key cisco

aaa group server radius AAA_EXT_2
server name RAD_EXT_3
ip radius source-interface vlan 51

aaa authentication dot1x test_ext_2 group AAA_EXT_2

wlan test_wpa2 3 test_wpa3
security dot1x authentication-list test_ext_2
no shutdown

wireless profile policy pp-1
vlan 51
no shutdown
```



---

**Caution** Some clients might not be able to connect to WLANs properly if they detect the same SSID with multiple security policies. Use this feature with care.

---

#### Related Topics

[Creating WLANs \(CLI\)](#), on page 2870

[Configuring General WLAN Properties \(CLI\)](#), on page 2873  
[Deleting WLANs \(CLI\)](#), on page 2871  
[Configuring Advanced WLAN Properties \(CLI\)](#), on page 2875  
[Band Selection](#), on page 2864  
[DTIM Period](#)  
[Session Timeout](#)  
[Cisco Client Extensions](#), on page 2865  
[Peer-to-Peer Blocking](#), on page 2866  
[Diagnostic Channel](#)  
[Client Count Per WLAN](#)  
[Enabling WLANs \(CLI\)](#), on page 2872  
[Disabling WLANs \(CLI\)](#), on page 2873

## How to Configure WLANs

### Creating WLANs (CLI)

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan profile-name wlan-id [ssid]</b>  <b>Example:</b> Device(config)# <b>wlan mywlan 34 mywlan-ssid</b>	Specifies the WLAN name and ID: <ul style="list-style-type: none"> <li>• For the <i>profile-name</i>, enter the profile name. The range is from 1 to 32 alphanumeric characters.</li> <li>• For the <i>wlan-id</i>, enter the WLAN ID. The range is from 1 to 512.</li> <li>• For the <i>ssid</i>, enter the Service Set Identifier (SSID) for this WLAN. If the SSID is not specified, the WLAN profile name is set as the SSID.</li> </ul> <p><b>Note</b> By default, the WLAN is disabled.</p>
<b>Step 3</b>	<b>end</b>  <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

**Related Topics**

[Prerequisites for WLANs](#), on page 2867

[Restrictions for WLANs](#), on page 2867

## Deleting WLANs (CLI)

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>no wlan wlan-name wlan-id ssid</b>  <b>Example:</b> Device(config)# <code>no wlan test2</code>	Deletes the WLAN. The arguments are as follows: <ul style="list-style-type: none"> <li>• The <i>wlan-name</i> is the WLAN profile name.</li> <li>• The <i>wlan-id</i> is the WLAN ID.</li> <li>• The <i>ssid</i> is the WLAN SSID name configured for the WLAN.</li> </ul> <p><b>Note</b> If you delete a WLAN that is part of an AP group, the WLAN is removed from the AP group and from the AP's radio.</p>
<b>Step 3</b>	<b>end</b>  <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

**Related Topics**

[Prerequisites for WLANs](#), on page 2867

[Restrictions for WLANs](#), on page 2867

## Searching WLANs (CLI)

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>show wlan summary</b>  <b>Example:</b> Device# <code>show wlan summary</code>	Displays the list of all WLANs configured on the device. You can search for the WLAN in the output.

**Example**

```
Device# show wlan summary
Number of WLANs: 4
```

WLAN	Profile Name	SSID	VLAN	Status
1	test1	test1-ssid	137	UP
3	test2	test2-ssid	136	UP
2	test3	test3-ssid	1	UP
45	test4	test4-ssid	1	DOWN

You can also use wild cards to search WLANs. For example `show wlan summary include variable`. Where variable is any search string in the output.

```
Device# show wlan summary | include test-wlan-ssid
1 test-wlan test-wlan-ssid 137 UP
```

## Enabling WLANs (CLI)

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan <i>profile-name</i></b> <b>Example:</b> Device# <code>wlan test4</code>	Enters WLAN configuration submode. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>no shutdown</b> <b>Example:</b> Device(config-wlan)# <code>no shutdown</code>	Enables the WLAN.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

**Related Topics**

[Prerequisites for WLANs](#), on page 2867

[Restrictions for WLANs](#), on page 2867

## Disabling WLANs (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan <i>profile-name</i></b> <b>Example:</b> Device# <code>wlan test4</code>	Enters WLAN configuration submode. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>shutdown</b> <b>Example:</b> Device(config-wlan) # <code>shutdown</code>	Disables the WLAN.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config) # <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 5</b>	<b>show wlan summary</b> <b>Example:</b> Device# <code>show wlan summary</code>	Displays the list of all WLANs configured on the device. You can search for the WLAN in the output.

### Related Topics

[Prerequisites for WLANs](#), on page 2867

[Restrictions for WLANs](#), on page 2867

## Configuring General WLAN Properties (CLI)

You can configure the following properties:

- Media stream
- Broadcast SSID
- Call Snooping
- Radio
- Interface
- Status

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan <i>profile-name</i></b> <b>Example:</b> Device# <code>wlan test4</code>	Enters WLAN configuration submenu. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>shutdown</b> <b>Example:</b> Device# <code>shutdown</code>	Disables the WLAN before configuring the parameters.
<b>Step 4</b>	<b>broadcast-ssid</b> <b>Example:</b> Device (config-wlan)# <code>broadcast-ssid</code>	Broadcasts the SSID for this WLAN. This field is enabled by default.
<b>Step 5</b>	<b>radio {all   dot11a   dot11ag   dot11bg   dot11g}</b> <b>Example:</b> Device# <code>radio all</code>	Enables radios on the WLAN. The keywords are as follows: <ul style="list-style-type: none"> <li>• <b>all</b>—Configures the WLAN on all radio bands.</li> <li>• <b>dot11a</b>—Configures the WLAN on only 802.11a radio bands.</li> <li>• <b>dot11g</b>—Configures the WLAN on 802.11ag radio bands.</li> <li>• <b>dot11bg</b>—Configures the WLAN on only 802.11b/g radio bands (only 802.11b if 802.11g is disabled).</li> <li>• <b>dot11ag</b>— Configures the wireless LAN on 802.11g radio bands only.</li> </ul>
<b>Step 6</b>	<b>client vlan <i>vlan-identifier</i></b> <b>Example:</b> Device# <code>client vlan test-vlan</code>	Enables an interface group on the WLAN. <i>vlan-identifier</i> —Specifies the VLAN identifier. This can be the VLAN name, VLAN ID, or VLAN group name.
<b>Step 7</b>	<b>ip multicast vlan <i>vlan-name</i></b> <b>Example:</b> Device (config-wlan)# <code>ip multicast vlan test</code>	Enables IP multicast on a WLAN. The keywords are as follows: <ul style="list-style-type: none"> <li>• <b>vlan</b>—Specifies the VLAN ID.</li> <li>• <i>vlan-name</i>—Specifies the VLAN name.</li> </ul>



	Command or Action	Purpose
<b>Step 8</b>	<b>media-stream multicast-direct</b> <b>Example:</b> Device(config-wlan)# <b>media-stream multicast-direct</b>	Enables multicast VLANs on this WLAN.
<b>Step 9</b>	<b>call-snoop</b> <b>Example:</b> Device(config-wlan)# <b>call-snoop</b>	Enables call-snooping support.
<b>Step 10</b>	<b>no shutdown</b> <b>Example:</b> Device(config-wlan)# <b>no shutdown</b>	Enables the WLAN.
<b>Step 11</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

**Related Topics**

[Prerequisites for WLANs](#), on page 2867

[Restrictions for WLANs](#), on page 2867

## Configuring Advanced WLAN Properties (CLI)

You can configure the following advanced properties:

- AAA Override
- Coverage Hole Detection
- Session Timeout
- Cisco Client Extensions
- Diagnostic Channels
- Interface Override ACLs
- P2P Blocking
- Client Exclusion
- Maximum Clients Per WLAN
- Off Channel Scan Defer

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan profile-name</b> <b>Example:</b> Device# <b>wlan test4</b>	Enters WLAN configuration submenu. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>aaa-override</b> <b>Example:</b> Device (config-wlan) # <b>aaa-override</b>	Enables AAA override.
<b>Step 4</b>	<b>chd</b> <b>Example:</b> Device (config-wlan) # <b>chd</b>	Enables coverage hole detection for this WLAN. This field is enabled by default.
<b>Step 5</b>	<b>session-timeout time-in-seconds</b> <b>Example:</b> Device (config-wlan) # <b>session-timeout 450</b>	Sets the session timeout in seconds. The range and default values vary according to the security configuration. If the WLAN security is configured to dot1x, the range is 300 to 86400 seconds and the default value is 1800 seconds. For all other WLAN security configurations, the range is 1 to 65535 seconds and the default value is 0 seconds. A value of 0 indicates no session timeout.
<b>Step 6</b>	<b>ccx aironet-iesupport</b> <b>Example:</b> Device (config-wlan) # <b>ccx aironet-iesupport</b>	Enables support for Aironet IEs for this WLAN. This field is enabled by default.
<b>Step 7</b>	<b>diag-channel</b> <b>Example:</b> Device (config-wlan) # <b>diag-channel</b>	Enables diagnostic channel support to troubleshoot client communication issues on a WLAN.
<b>Step 8</b>	<b>ip access-group [web] acl-name</b> <b>Example:</b> Device (config) # <b>ip access-group test-acl-name</b>	Configures the WLAN ACL group. The variable <i>acl-name</i> specifies the user-defined IPv4 ACL name. The keyword <b>web</b> specifies the IPv4 web ACL.
<b>Step 9</b>	<b>peer-blocking [drop   forward-upstream]</b> <b>Example:</b> Device (config) # <b>peer-blocking drop</b>	Configures peer to peer blocking parameters. The keywords are as follows: <ul style="list-style-type: none"> <li>• <b>drop</b>—Enables peer-to-peer blocking on the drop action.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• <b>forward-upstream</b>—Enables peer-to-peer blocking on the forward upstream action.</li> </ul>
<b>Step 10</b>	<b>exclusionlist</b> <i>time-in-seconds</i> <b>Example:</b> Device (config) # <b>exclusionlist 10</b>	Specifies the timeout in seconds. The valid range is from 0 to 2147483647. Enter 0 for no timeout. A zero (0) timeout indicates that the client is permanently added to the exclusion list.
<b>Step 11</b>	<b>client association limit</b> <i>max-number-of-clients</i> <b>Example:</b> Device (config) # <b>client association limit 200</b>	Sets the maximum number of clients that can be configured on a WLAN.
<b>Step 12</b>	<b>channel-scan defer-priority</b> { <b>defer-priority</b> {0-7}   <b>defer-time</b> {0 - 6000}} <b>Example:</b> Device (config) # <b>channel-scan defer-priority 6</b>	Sets the channel scan defer priority and defer time. The arguments are as follows: <ul style="list-style-type: none"> <li>• <b>defer-priority</b>—Specifies the priority markings for packets that can defer off-channel scanning. The range is from 0 to 7. The default is 3.</li> <li>• <b>defer-time</b>—Deferral time in milliseconds. The range is from 0 to 6000. The default is 100.</li> </ul>
<b>Step 13</b>	<b>end</b> <b>Example:</b> Device (config) # <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

### Related Topics

- [Band Selection](#), on page 2864
- [DTIM Period](#)
- [Session Timeout](#)
- [Cisco Client Extensions](#), on page 2865
- [Peer-to-Peer Blocking](#), on page 2866
- [Diagnostic Channel](#)
- [Client Count Per WLAN](#)
- [Prerequisites for WLANs](#), on page 2867
- [Restrictions for WLANs](#), on page 2867
- [Information About AAA Override](#), on page 2908
- [Prerequisites for Layer 2 Security](#), on page 2907

## Monitoring WLAN Properties (CLI)

Command	Description
<code>show wlan id <i>wlan-id</i></code>	Displays WLAN properties based on the WLAN ID.
<code>show wlan name <i>wlan-name</i></code>	Displays WLAN properties based on the WLAN name.
<code>show wlan all</code>	Displays WLAN properties of all configured WLANs.
<code>show wlan summary</code>	Displays a summary of all WLANs. The summary details includes the following information: <ul style="list-style-type: none"> <li>• WLAN ID</li> <li>• Profile name</li> <li>• SSID</li> <li>• VLAN</li> <li>• Status</li> </ul>
<code>show running-config wlan <i>wlan-name</i></code>	Displays the running configuration of a WLAN based on the WLAN name.
<code>show running-config <i>wlan</i></code>	Displays the running configuration of all WLANs.

## Where to Go Next

Proceed to configure DHCP for WLANs.

## Additional References

### Related Documents

Related Topic	Document Title
WLAN command reference	<i>WLAN Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>
Mobility Anchor configuration	<i>Mobility Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>
WebAuth Configuration	<i>Security Configuration Guide (Catalyst 3850 Switches)</i>

**Error Message Decoder**

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**MIBs**

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for WLANs

This table lists the features in this module and provides links to specific configuration information:

Feature	Release	Modification
WLAN Functionality	Cisco IOS XE 3.2SE	This feature was introduced.





## CHAPTER 161

# Configuring Remote-LAN

- [Finding Feature Information](#), on page 2881
- [Prerequisites for Configuring Remote-LAN](#), on page 2881
- [Restrictions for Remote-LAN](#), on page 2881
- [Information About Remote-LAN](#), on page 2882
- [Configuring Remote-LAN \(CLI\)](#), on page 2882
- [Configuration Examples for Remote-LAN](#), on page 2884
- [Configuring AP Group-Specific CLIs](#), on page 2886
- [Configuring PoE for a Port](#), on page 2887
- [Configuring LAN Override for an AP](#), on page 2888

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Configuring Remote-LAN

- The Remote-LAN feature is supported in Cisco IOS XE Denali 16.3.1 release and later. This feature is available on the Cisco Aironet 1810W Series AP, which offer compact, wall plate-mountable access point.

## Restrictions for Remote-LAN

- Same profile names or IDs cannot be used for both WLANs and remote LANs.
- Only three clients can connect to a Cisco Aironet 1810W Series AP through local Gigabit Ethernet ports. Each port supports only one client.

- Remote-LAN profiles can be mapped only to an AP group. Hence, an AP should be in an AP group to configure Remote-LAN profile in its local Gigabit Ethernet ports.
- The Default AP group cannot be configured for Remote-LAN.

## Information About Remote-LAN

Remote-LAN is similar to a WLAN, the only difference being that a WLAN is used for wireless connection, but a Remote-LAN is used for wired ports. Cisco Aironet 1810W Series AP come with three local Gigabit Ethernet ports, one uplink Gigabit Ethernet port, and one passive passthrough RJ-45 port. Configuring a Remote-LAN profile on a local Gigabit Ethernet port enables the traffic from wired devices to connect to the ports tunneled back to a wireless controller.

## Configuring Remote-LAN (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>remote-lan</b> <i>profile-name id</i> <b>Example:</b> Device(config)# <b>remote-lan test-lan 3</b>	Specifies the Remote-LAN profile name. <ul style="list-style-type: none"> <li>• <b>id</b>—Unique number entered during configuration tasks. Range is from 1 to 64.</li> </ul>
<b>Step 2</b>	<b>session-timeout</b> <i>session-time</i> <b>Example:</b> Device(config-remote-lan)# <b>session-timeout 50</b>	Sets the duration of session, in seconds. Range is from 0 to 86400.
<b>Step 3</b>	<b>client vlan</b> <i>vlan-identifier</i> <b>Example:</b> Device(config-remote-lan)# <b>client vlan test-vlan</b>	Enables an interface group on the Remote-LAN. <ul style="list-style-type: none"> <li>• <b>vlan-identifier</b>—Specifies the VLAN identifier. It can be the VLAN name, VLAN ID, or VLAN group name.</li> </ul>
<b>Step 4</b>	<b>client association limit</b> <i>max-number-of-clients</i> <b>Example:</b> Device(config-remote-lan)# <b>client association limit 200</b>	Sets the maximum number of clients that can be connected to the Remote-LAN profile.
<b>Step 5</b>	<b>ip access-group</b> <i>acl-name</i> <b>Example:</b> Device(config-remote-lan)# <b>ip access-group acl-name</b>	Configures the IPv4 ACL name or ID.



	Command or Action	Purpose
<b>Step 6</b>	<b>security webauth parameter-map parameter-name</b>  <b>Example:</b> Device(config-remote-lan) # <b>security web-auth parameter-map parameter-22</b>	Specifies the parameter map name.
<b>Step 7</b>	<b>security dot1x</b>  <b>Example:</b> Device(config-remote-lan) # <b>security dot1x</b>	Specifies 802.1X security.
<b>Step 8</b>	<b>security dot1x authentication list-name</b>  <b>Example:</b> Device(config-remote-lan) # <b>security dot1x authentication-list LIST1</b>	Sets the Authentication List name.
<b>Step 9</b>	<b>exclusionlist timeout time-sec</b>  <b>Example:</b> Device(config-remote-lan) # <b>exclusionlist timeout 30</b>	Sets time in seconds, after which a client is excluded. Range is from 0 to 2147483647. The value 0 stands for no timeout.
<b>Step 10</b>	<b>aaa-override</b>  <b>Example:</b> Device(config-remote-lan) # <b>aaa-override</b>	Overrides the AAA policy.
<b>Step 11</b>	<b>local-auth EAP-Profile</b>  <b>Example:</b> Device(config-remote-lan) # <b>local-auth EAP-Profile</b>	Enables the EAP profile on a Remote-LAN.
<b>Step 12</b>	<b>ip dhcp server ip-address</b>  <b>Example:</b> Device(config-remote-lan) # <b>ip dhcp server 10.76.47.11</b>	Configures DHCP parameters for Remote-LAN.
<b>Step 13</b>	<b>ip access-group web acl-name</b>  <b>Example:</b> Device(config-remote-lan) # <b>ip access-group web acl-test</b>	Configures the IPv4 Remote-LAN Web ACL.
<b>Step 14</b>	<b>accounting-list list-name</b>  <b>Example:</b> Device(config-remote-lan) # <b>accounting-list list-LIST1</b>	Sets the accounting list for IEEE 802.1x.

	Command or Action	Purpose
<b>Step 15</b>	<b>mac-filtering</b> <i>list-name</i> <b>Example:</b> Device(config-remote-lan)# <b>mac-filtering</b> <b>test-10</b>	Sets MAC filtering support on Remote-LAN.
<b>Step 16</b>	<b>no shutdown</b> <b>Example:</b> Device(config-remote-lan)# <b>no shutdown</b>	Enables Remote-LAN.

## Configuration Examples for Remote-LAN

The following example shows a summary of all the Remote-LANs:

```
Device# show remote-lan summary
Number of Remote-LANs: 1

Remote-LAN Profile Name          VLAN Status
-----
2          test                   1      DOWN
```

The following example shows a Remote-LAN configuration by ID:

```
Device# show remote-lan id 2
Remote-LAN Profile Name      : test
=====
Identifier                   : 2
Status                       : Disabled
Universal AP Admin          : Disabled
Max Associated Clients per Remote-LAN : 0
AAA Policy Override         : Enabled
Number of Active Clients    : 0
Exclusionlist Timeout       : 21474
Session Timeout             : 864 seconds
Interface                   : default
Interface Status            : Up
Remote-LAN ACL              : testacl
DHCP Server                  : 10.5.7.9
DHCP Address Assignment Required : Disabled
Local EAP Authentication    : testeaprofile
Mac Filter Authorization list name : testmaclist
Accounting list name        : testlist
802.1x authentication list name : dotxauth
Security
  802.11 Authentication     : Open System
  802.1X                    : Enabled
  Encryption                : 104-bit WEP
```

The following example shows a Remote-LAN configuration by profile name:

```
Device# show remote-lan name test
Remote-LAN Profile Name : test
=====
```

```

Identifier : 1
Status : Disabled
Universal AP Admin : Disabled
Max Associated Clients per Remote-LAN : 0
AAA Policy Override : Disabled
Number of Active Clients : 0
Exclusionlist Timeout : 60
Session Timeout : 1800 seconds
Interface : default
Interface Status : Up
Remote-LAN ACL : unconfigured
DHCP Server : 0.0.0.0
DHCP Address Assignment Required : Disabled
Local EAP Authentication : Disabled
Mac Filter Authorization list name : Disabled
Accounting list name : Disabled
802.1x authentication list name : Disabled
Security
802.11 Authentication : Open System
802.1X : Disabled
Web Based Authentication : Disabled
Conditional Web Redirect : Disabled
Splash-Page Web Redirect : Disabled
Webauth On-mac-filter Failure : Disabled
Webauth Authentication List Name : Disabled
Webauth Parameter Map : Disabled

```

The following example shows the Remote-LAN properties of all the configured Remote-LANs:

```

Device# show remote-lan all
Remote-LAN Profile Name : test
=====
Identifier : 1
Status : Disabled
Universal AP Admin : Disabled
Max Associated Clients per Remote-LAN : 0
AAA Policy Override : Disabled
Number of Active Clients : 0
Exclusionlist Timeout : 60
Session Timeout : 1800 seconds
Interface : default
Interface Status : Up
Remote-LAN ACL : unconfigured
DHCP Server : 0.0.0.0
DHCP Address Assignment Required : Disabled
Local EAP Authentication : Disabled
Mac Filter Authorization list name : Disabled
Accounting list name : Disabled
802.1x authentication list name : Disabled
Security
802.11 Authentication : Open System
802.1X : Disabled
Web Based Authentication : Disabled
Conditional Web Redirect : Disabled
Splash-Page Web Redirect : Disabled
Webauth On-mac-filter Failure : Disabled
Webauth Authentication List Name : Disabled
Webauth Parameter Map : Disabled

```

The following example shows a Remote-LAN configuration:

```

Device# show running-config remote-lan test
remote-lan test 1

```

```

aaa-override
accounting-list test-all-list
exclusionlist timeout 100
ip access-group test-acl
ip dhcp server 10.100.12.5
mac-filtering test-mac-list
security dot1x authentication-list test-dot1x-list
session-timeout 100
shutdown

```

The following example shows the details of the AP groups:

```

Device# show ap groups
Site Name: test-ap-group
Site Description:
Hyperlocation Operational Status: Down

WLAN ID WLAN Name Interface
-----
LAN Status PoE Remote-LAN
-----
1 Down Disabled None
2 Down None
3 Down None

```

The following example shows the details of a LAN port:

```

Device# show ap name AP00FE.C82D.E7B0 lan port 1
LAN Port status for AP AP00FE.C82D.E7B0

LanOverride Enabled

PortId Status VlanId PoE
-----
LAN1 Enabled 0 Disabled

```

The following example shows the details of a LAN port summary:

```

Device# show ap name AP00FE.C82D.E7B0 lan port summary
LAN Port status for AP AP00FE.C82D.E7B0

LanOverride Enabled

Port ID Status Vlan ID PoE
-----
LAN1 Enabled 0 Disable
LAN2 Disabled 0 Disable
LAN3 Disabled 0 Disable

```

## Configuring AP Group-Specific CLIs

Use the following procedure to configure the LAN port parameters for an AP group:

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>remote-lan</b> <i>remote-lan-name</i> <b>Example:</b> Device(config-apgroup)# <b>remote-lan</b> <b>test-lan</b>	Adds a Remote-LAN to an AP group.
<b>Step 2</b>	<b>port</b> <i>port-id</i> <b>Example:</b> Device(config-apgroup)# <b>port 1</b>	Configures the port ID of an AP group.
<b>Step 3</b>	<b>poe</b> <b>Example:</b> Device(config-port-apgroup)# <b>poe</b>	Enables a PoE on the port. <b>Note</b> PoE can be configured only for port 1.
<b>Step 4</b>	<b>remote-lan</b> <i>remote-lan-name</i> <b>Example:</b> Device(config-port-apgroup)# <b>remote-lan</b> <b>test-lan</b>	Adds a Remote-LAN ID.
<b>Step 5</b>	<b>no shutdown</b> <b>Example:</b> Device(config-port-apgroup)# <b>no shutdown</b>	Enables the LAN port.

## Configuring PoE for a Port

The Cisco Aironet 1810W Series allows wired access via Power over Ethernet (PoE). This feature provides wired access with PoE for other devices, such as IP phones, security cameras, printers, and copiers. Only LAN Port 1 should be configured for the PoE to be enabled or disabled. By default, PoE is disabled for the port.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>ap name</b> <i>ap-name</i> <b>lan port-id</b> <i>port-id</i> <b>poe</b> <b>Example:</b> Device# <b>ap name</b> AP00FE.C82D.DFB0 <b>lan</b> <b>port-id 1 poe</b>	Enables PoE for the LAN port of an AP. <b>Note</b> PoE can be configured only for port 1.

## Configuring LAN Override for an AP

LAN override can be enabled to override a LAN port configuration for a particular AP. Per-AP LAN port configurations work only when LAN override is enabled. By default, LAN override is disabled. With LAN override disabled, an AP uses AP group LAN port configurations.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>ap name <i>ap-name</i> lan override</b> <b>Example:</b> Device# <b>ap name AP00FE.C82D.DFB0 lan override</b>	Enables override for AP group LAN port configurations.



## CHAPTER 162

# DHCP for WLANs

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- [Information About the Dynamic Host Configuration Protocol, on page 2889](#)
- [Prerequisites for Configuring DHCP for WLANs, on page 2892](#)
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## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About the Dynamic Host Configuration Protocol

You can configure WLANs to use the same or different Dynamic Host Configuration Protocol (DHCP) servers or no DHCP server. Two types of DHCP servers are available: internal and external.

### Internal DHCP Servers

The devices contain an internal DHCP server. This server is typically used in branch offices that do not already have a DHCP server. The wireless network generally contains a maximum of 10 APs or less, with the APs on the same IP subnet as the device. The internal server provides DHCP addresses to wireless clients, direct-connect APs, and DHCP requests that are relayed from APs. Only lightweight access points are supported. When you want to use the internal DHCP server, you must set the management interface IP address of the device as the DHCP server IP address.

DHCP option 43 is not supported on the internal server. Therefore, the access point must use an alternative method to locate the management interface IP address of the device, such as local subnet broadcast, Domain Name System (DNS), or priming.

An internal DHCP server pool only serves the wireless clients of that device, not clients of other devices. Also, an internal DHCP server can serve only wireless clients, not wired clients.

When clients use the internal DHCP server of the device, IP addresses are not preserved across reboots. As a result, multiple clients can be assigned to the same IP address. To resolve any IP address conflicts, clients must release their existing IP address and request a new one. Wired guest clients are always on a Layer 2 network connected to a local or foreign device.

**Note**

- VRF is not supported in the internal DHCP servers.
- DHCPv6 is not supported in the internal DHCP servers.

**General Guidelines**

## External DHCP Servers

The operating system is designed to appear as a DHCP Relay to the network and as a DHCP server to clients with industry-standard external DHCP servers that support DHCP Relay, which means that each device appears as a DHCP Relay agent to the DHCP server and as a DHCP server at the virtual IP address to wireless clients.

Because the device captures the client IP address that is obtained from a DHCP server, it maintains the same IP address for that client during intra device, inter device, and inter-subnet client roaming.

**Note**

External DHCP servers can support DHCPv6.

## DHCP Assignments

You can configure DHCP on a per-interface or per-WLAN basis. We recommend that you use the primary DHCP server address that is assigned to a particular interface.

You can assign DHCP servers for individual interfaces. You can configure the management interface, AP-manager interface, and dynamic interface for a primary and secondary DHCP server, and you can configure the service-port interface to enable or disable DHCP servers. You can also define a DHCP server on a WLAN. In this case, the server overrides the DHCP server address on the interface assigned to the WLAN.

**Security Considerations**

For enhanced security, we recommend that you require all clients to obtain their IP addresses from a DHCP server. To enforce this requirement, you can configure all WLANs with a DHCP Addr. Assignment Required setting, which disallows client static IP addresses. If DHCP Addr. Assignment Required is selected, clients must obtain an IP address via DHCP. Any client with a static IP address is not allowed on the network. The device monitors DHCP traffic because it acts as a DHCP proxy for the clients.





- Note**
- WLANs that support management over wireless must allow management (device-servicing) clients to obtain an IP address from a DHCP server.

If slightly less security is tolerable, you can create WLANs with DHCP Addr. Assignment Required disabled. Clients then have the option of using a static IP address or obtaining an IP address from a designated DHCP server.



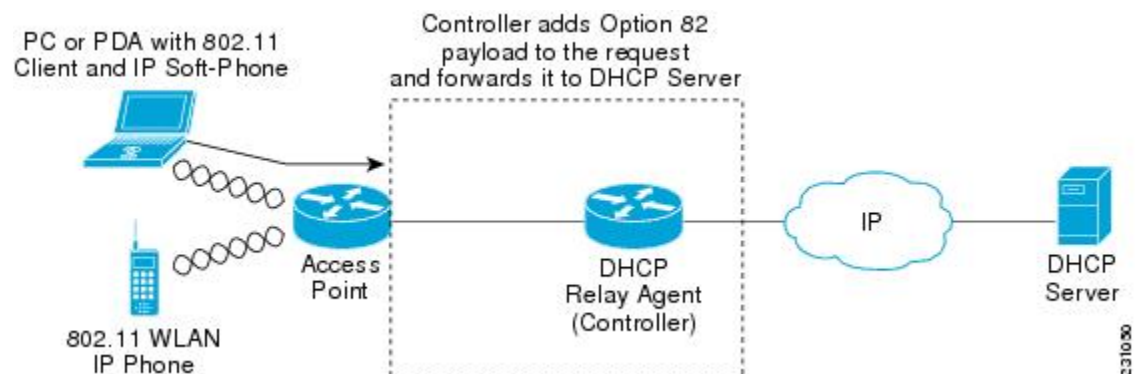
- Note** DHCP Addr. Assignment Required is not supported for wired guest LANs.

You can create separate WLANs with DHCP Addr. Assignment Required configured as disabled. This is applicable only if DHCP proxy is enabled for the device. You must not define the primary/secondary configuration DHCP server you should disable the DHCP proxy. These WLANs drop all DHCP requests and force clients to use a static IP address. These WLANs do not support management over wireless connections.

## Information About DHCP Option 82

DHCP option 82 provides additional security when DHCP is used to allocate network addresses. It enables the device to act as a DHCP relay agent to prevent DHCP client requests from untrusted sources. You can configure the device to add option 82 information to DHCP requests from clients before forwarding the requests to the DHCP server.

**Figure 152: DHCP Option 82**



The access point forwards all DHCP requests from a client to the device. The device adds the DHCP option 82 payload and forwards the request to the DHCP server. The payload can contain the MAC address or the MAC address and SSID of the access point, depending on how you configure this option.



- Note** Any DHCP packets that already include a relay agent option are dropped at the device.

For DHCP option 82 to operate correctly, DHCP proxy must be enabled.

## Configuring DHCP Scopes

### Information About Internal DHCP Server

Devices have built-in DHCP relay agents. However, when you desire network segments that do not have a separate DHCP server, the devices can have built-in internal DHCP server that assign IP addresses and subnet masks to wireless clients. Typically, one device can have one or more internal DHCP server that each provide a range of IP addresses.

Internal DHCP server are needed for internal DHCP to work. Once DHCP is defined on the device, you can then point the primary DHCP server IP address on the management, AP-manager, and dynamic interfaces to the device's management interface.



**Note** The controller has the ability to provide internal DHCP server. This feature is very limited and considered as convenience that is often used simple demonstration or proof-of-concept, for example in a lab environment. The best practice is NOT to use this feature in an enterprise production network.

Read more about this at: <http://www.cisco.com/c/en/us/support/docs/wireless/4400-series-wireless-lan-controllers/110865-dhcp-wlc.html#anc16>

## Prerequisites for Configuring DHCP for WLANs

- To be able to use the DHCP option 82, you must configure DHCP on Cisco IOS software. By default, DHCP option 82 is enabled for all clients. You can control the wireless client behavior using the WLAN suboptions.
- The Cisco converged access platforms support internal DHCP server functionality. However, as a general deployment guideline to build large enterprise-class networks, we recommend that you use external DHCP server to provide dynamic IP addressing to wireless clients. Such distributed function reduces processing and configuration load on network devices and allows them to operate efficiently in large scale deployments.
- DHCP Snooping Configuration—DHCP snooping configuration is the required best practices configuration on for rapid client join function. DHCP snooping needs to be enabled on each client VLAN including the override VLAN if override is applied on the WLAN.

#### Example of DHCP snooping configuration

##### 1. Global DHCP snooping configuration:

a. `Device(config)#ip dhcp snooping`

`Device(config)#ip dhcp snooping vlan 100`

b. Enable `bootp-broadcast` command. This is required for clients that send DHCP messages with broadcast addresses and broadcast bit is set in the DHCP message:

`Device(config)#ip dhcp snooping wireless bootp-broadcast enable`

c. To not append DHCP Option information, enter this command:

`Device(config)#no ip dhcp snooping information option`

2. On the interface:



---

**Note** IP DHCP snooping trust is required on Port-Channel interface in addition to member link of the Port-Channel interface.

---

```
Device(config)#interface range TenGigabitEthernet 1/0/1 - 2
```

```
Device(config-if)#switchport mode trunk
```

```
Device(config-if)#switchport trunk allowed vlan 100
```

```
Device(config-if)#ip dhcp snooping trust
```

```
Device(config)#interface port-channel 1
```

```
Device(config-if)#switchport mode trunk
```

```
Device(config-if)#switchport trunk allowed vlan 100
```

```
Device(config-if)#ip dhcp snooping trust
```



---

**Note** DHCP snooping must be configured on the Guest Anchor for guest access similar to the Config above.

---

## Restrictions for Configuring DHCP for WLANs

- If you override the DHCP server in a WLAN, you must ensure that you configure the underlying Cisco IOS configuration to make sure that the DHCP server is reachable.
- WLAN DHCP override works only if DHCP service is enabled on the device.

You can configure DHCP service in either of the following ways:

- Configuring the DHCP pool on the device.
- Configuring a DHCP relay agent on the SVI. Note: the VLAN of the SVI must be mapped to the WLAN where DHCP override is configured.

## How to Configure DHCP for WLANs

### Configuring DHCP for WLANs (CLI)

Use this procedure to configure the following DHCP parameters on a WLAN:

- DHCP Option 82 Payload

- DHCP Required
- DHCP Override

### Before you begin

- You must have admin privileges for configuring the WLAN.
- To configure the DHCP override, you must have the IP address of the DHCP server.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>shutdown</b> <b>Example:</b> Device(config)# <b>shutdown</b>	Shut down the WLAN.
<b>Step 3</b>	<b>wlan profile-name</b> <b>Example:</b> Device# <b>wlan test4</b>	Enters WLAN configuration submode. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 4</b>	<b>ip dhcp opt82 {ascii   format {add-ssid   ap-ethmac}   rid}</b> <b>Example:</b> Device(config)# <b>ip dhcp opt82 format add-ssid</b>	Specifies the DHCP82 payload on the WLAN. The keyword and arguments are as follows: <ul style="list-style-type: none"> <li>• <b>ascii</b>—Configures ASCII for DHCP Option 82. If this is not configured, the option 82 format is set to ASCII format.</li> <li>• <b>format</b>—Specifies the DHCP option 82 format. The following options are available:               <ul style="list-style-type: none"> <li>• <i>add-ssid</i>—Set RemoteID format that is the AP radio MAC address and SSID.</li> <li>• <i>ap-ethmac</i>—Set RemoteID format that is the AP Ethernet MAC address.</li> </ul> </li> </ul> <p><b>Note</b> If the format option is not configured, only the AP radio MAC address is used.</p> <ul style="list-style-type: none"> <li>• <b>rid</b>—Adds the Cisco 2 byte RID for DHCP option 82.</li> </ul>

	Command or Action	Purpose
<b>Step 5</b>	<b>ip dhcp required</b> <b>Example:</b> Device(config-wlan) # <b>ip dhcp required</b>	Makes it mandatory for clients to get their IP address from the DHCP server. Static clients are not allowed.
<b>Step 6</b>	<b>ip dhcp server ip-address</b> <b>Example:</b> Device(config-wlan) # <b>ip dhcp server 200.1.1.2</b>	Defines a DHCP server on the WLAN that overrides the DHCP server address on the interface assigned to the WLAN.
<b>Step 7</b>	<b>no shutdown</b> <b>Example:</b> Device(config-wlan) # <b>no shutdown</b>	Restarts the WLAN.
<b>Step 8</b>	<b>end</b> <b>Example:</b> Device(config) # <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.
<b>Step 9</b>	<b>show wlan wlan-name</b> <b>Example:</b> Device(config-wlan) # <b>show wlan test-wlan</b>	Verifies the DHCP configuration.

## Configuring DHCP Scopes (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>ip dhcp pool pool-name</b> <b>Example:</b> Device(config) # <b>ip dhcp pool test-pool</b>	Configures the DHCP pool address.
<b>Step 3</b>	<b>network network-name mask-address</b> <b>Example:</b> Device(dhcp-config) # <b>network 209.165.200.224 255.255.255.0</b>	Specifies the network number in dotted-decimal notation and the mask address.
<b>Step 4</b>	<b>dns-server hostname</b> <b>Example:</b> Device(dhcp-config) # <b>dns-server example.com</b>	Specifies the DNS name server. You can specify an IP address or a hostname.

	Command or Action	Purpose
<b>Step 5</b>	<b>end</b>  <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Configuring Internal DHCP Server

### Configuring Internal DHCP Server Under Client VLAN SVI

#### Before you begin

- To use the internal DHCP server for both wireless and wired client VLAN, an IP address must be configured under the client VLAN switched virtual interfaces (SVI) interface.
- For wireless clients, the IP address of the internal DHCP server must be different from the address of the wireless client VLAN SVI interface (in DHCP helper address configuration).
- For wireless clients, the internal DHCP server can be configured under the client VLAN SVI interface or under the wireless policy profile.

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>interface loopback <i>interface-number</i></b>  <b>Example:</b> Device(config)# <code>interface Loopback0</code>	Creates a loopback interface and enters interface configuration mode.
<b>Step 3</b>	<b>ip address <i>ip-address</i></b>  <b>Example:</b> Device(config-if)# <code>ip address 10.10.10.1 255.255.255.255</code>	Configures the IP address for the interface.
<b>Step 4</b>	<b>exit</b>  <b>Example:</b> Device(config-if)# <code>exit</code>	Exits interface configuration mode.
<b>Step 5</b>	<b>interface vlan <i>vlan-id</i></b>  <b>Example:</b> Device(config)# <code>interface vlan 32</code>	Configures the VLAN ID.

	Command or Action	Purpose
<b>Step 6</b>	<b>ip address</b> <i>ip-address</i>  <b>Example:</b> Device(config-if)# ip address 192.168.32.100 255.255.255.0	Configures the IP address for the interface.
<b>Step 7</b>	<b>ip helper-address</b> <i>ip-address</i>  <b>Example:</b> Device(config-if)# ip helper-address 10.10.10.1	Configures the destination address for UDP broadcasts.  <b>Note</b> If the IP address used in the <b>ip helper-address</b> command is an internal address of the controller, an internal DHCP server is used. Otherwise, the external DHCP server is used.
<b>Step 8</b>	<b>no mop enabled</b>  <b>Example:</b> Device(config-if)# no mop enabled	Disables the Maintenance Operation Protocol (MOP) for an interface.
<b>Step 9</b>	<b>no mop sysid</b>  <b>Example:</b> Device(config-if)# no mop sysid	Disables the task of sending MOP periodic system ID messages.
<b>Step 10</b>	<b>end</b>  <b>Example:</b> Device(config-if)# exit	Exits the interface configuration mode.
<b>Step 11</b>	<b>ip dhcp excluded-address</b> <i>ip-address</i>  <b>Example:</b> Device(config)# ip dhcp excluded-address 192.168.32.1	Specifies the IP address that the DHCP server should not assign to DHCP clients.
<b>Step 12</b>	<b>ip dhcp excluded-address</b> <i>ip-address</i>  <b>Example:</b> Device(config)# ip dhcp excluded-address 192.168.32.100	Specifies the IP addresses that the DHCP server should not assign to DHCP clients.
<b>Step 13</b>	<b>ip dhcp pool</b> <i>pool-name</i>  <b>Example:</b> Device(config)# ip dhcp pool pool-vlan32	Configures the DHCP pool address.
<b>Step 14</b>	<b>network</b> <i>network-name mask-address</i>  <b>Example:</b> Device(dhcp-config)# network 192.168.32.0 255.255.255.0	Specifies the network number in dotted-decimal notation, along with the mask address.

	Command or Action	Purpose
<b>Step 15</b>	<b>default-router</b> <i>ip-address</i> <b>Example:</b> Device (dhcp-config) # default-router 192.168.32.1	Specifies the IP address of the default router for a DHCP client.
<b>Step 16</b>	<b>exit</b> <b>Example:</b> Device (dhcp-config) # exit	Exits DHCP configuration mode.
<b>Step 17</b>	<b>wireless profile policy</b> <i>profile-policy</i> <b>Example:</b> Device (config) # wireless profile policy default-policy-profile	Configures the WLAN policy profile and enters the wireless policy configuration mode.
<b>Step 18</b>	<b>central association</b> <b>Example:</b> Device (config-wireless-policy) # central association	Configures central association for locally switched clients.
<b>Step 19</b>	<b>central dhcp</b> <b>Example:</b> Device (config-wireless-policy) # central dhcp	Configures the central DHCP for locally switched clients.
<b>Step 20</b>	<b>central switching</b> <b>Example:</b> Device (config-wireless-policy) # central switching	Configures WLAN for central switching.
<b>Step 21</b>	<b>description</b> <i>policy-profile-name</i> <b>Example:</b> Device (config-wireless-policy) # description "default policy profile"	Adds a description for the policy profile
<b>Step 22</b>	<b>vlan</b> <i>vlan-name</i> <b>Example:</b> Device (config-wireless-policy) # vlan 32	Assigns the profile policy to the VLAN.
<b>Step 23</b>	<b>no shutdown</b> <b>Example:</b> Device (config-wireless-policy) # no shutdown	Enables the profile policy.



## Configuring the Internal DHCP Server Under a Wireless Policy Profile

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 2</b>	<b>interface loopback <i>interface-number</i></b> <b>Example:</b> Device(config)# interface Loopback0	Creates a loopback interface and enters interface configuration mode.
<b>Step 3</b>	<b>ip address <i>ip-address</i></b> <b>Example:</b> Device(config-if)# ip address 10.10.10.1 255.255.255.255	Configures the IP address for the interface.
<b>Step 4</b>	<b>exit</b> <b>Example:</b> Device(config-if)# exit	Exits interface configuration mode.
<b>Step 5</b>	<b>interface vlan <i>vlan-id</i></b> <b>Example:</b> Device(config)# interface vlan 32	Configures the VLAN ID.
<b>Step 6</b>	<b>ip address <i>ip-address</i></b> <b>Example:</b> Device(config-if)# ip address 192.168.32.100 255.255.255.0	Configures the IP address for the interface.
<b>Step 7</b>	<b>no mop enabled</b> <b>Example:</b> Device(config-if)# no mop enabled	Disables the Maintenance Operation Protocol (MOP) for an interface.
<b>Step 8</b>	<b>no mop sysid</b> <b>Example:</b> Device(config-if)# no mop sysid	Disables the task of sending MOP periodic system ID messages.
<b>Step 9</b>	<b>exit</b> <b>Example:</b> Device(config-if)# exit	Exits interface configuration mode.
<b>Step 10</b>	<b>ip dhcp excluded-address <i>ip-address</i></b> <b>Example:</b>	Specifies the IP addresses that the DHCP server should not assign to DHCP clients.

	Command or Action	Purpose
	Device(config)# ip dhcp excluded-address 192.168.32.1	
<b>Step 11</b>	<b>ip dhcp excluded-address</b> <i>ip-address</i> <b>Example:</b> Device(config)# ip dhcp excluded-address 192.168.32.100	Specifies the IP address that the DHCP server should not assign to DHCP clients.
<b>Step 12</b>	<b>ip dhcp pool</b> <i>pool-name</i> <b>Example:</b> Device(config)# ip dhcp pool pool-vlan32	Configures the DHCP pool address.
<b>Step 13</b>	<b>network</b> <i>network-name mask-address</i> <b>Example:</b> Device(dhcp-config)# network 192.168.32.0 255.255.255.0	Specifies the network number in dotted-decimal notation along with the mask address.
<b>Step 14</b>	<b>default-router</b> <i>ip-address</i> <b>Example:</b> Device(dhcp-config)# default-router 192.168.32.1	Specifies the IP address of the default router for a DHCP client.
<b>Step 15</b>	<b>exit</b> <b>Example:</b> Device(dhcp-config)# exit	Exits DHCP configuration mode.
<b>Step 16</b>	<b>wireless profile policy</b> <i>profile-policy</i> <b>Example:</b> Device(config)# wireless profile policy default-policy-profile	Configures a WLAN policy profile and enters wireless policy configuration mode.
<b>Step 17</b>	<b>central association</b> <b>Example:</b> Device(config-wireless-policy)# central association	Configures central association for locally switched clients.
<b>Step 18</b>	<b>central switching</b> <b>Example:</b> Device(config-wireless-policy)# central switching	Configures local switching.
<b>Step 19</b>	<b>description</b> <i>policy-profile-name</i> <b>Example:</b> Device(config-wireless-policy)# description "default policy profile"	Adds a description for the policy profile.

	Command or Action	Purpose
<b>Step 20</b>	<b>ipv4 dhcp opt82</b> <b>Example:</b> Device(config-wireless-policy)# ipv4 dhcp opt82	Enables DHCP Option 82 for the wireless clients.
<b>Step 21</b>	<b>ipv4 dhcp opt82 ascii</b> <b>Example:</b> Device(config-wireless-policy)# ipv4 dhcp opt82 ascii	Enables ASCII on DHCP Option82.
<b>Step 22</b>	<b>ipv4 dhcp opt82 format vlan_id</b> <b>Example:</b> Device(config-wireless-policy)# ipv4 dhcp opt82 format vlan32	Enables VLAN ID.
<b>Step 23</b>	<b>ipv4 dhcp opt82 rid vlan_id</b> <b>Example:</b> Device(config-wireless-policy)# ipv4 dhcp opt82 rid	Supports the addition of Cisco 2-byte Remote ID (RID) for DHCP Option82.
<b>Step 24</b>	<b>ipv4 dhcp server ip-address</b> <b>Example:</b> Device(config-wireless-policy)# ipv4 dhcp server 10.10.10.1	Configures the WLAN's IPv4 DHCP server.
<b>Step 25</b>	<b>vlan vlan-name</b> <b>Example:</b> Device(config-wireless-policy)# vlan 32	Assigns the profile policy to the VLAN.
<b>Step 26</b>	<b>no shutdown</b> <b>Example:</b> Device(config-wireless-policy)# no shutdown	Enables the profile policy.

## Configuring the Internal DHCP Server Globally

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>interface loopback</b> <i>interface-num</i> <b>Example:</b> Device(config)# interface Loopback0	Creates a loopback interface and enters interface configuration mode.
<b>Step 3</b>	<b>ip address</b> <i>ip-address</i> <b>Example:</b> Device(config-if)# ip address 10.10.10.1 255.255.255.255	Configures the IP address for the interface.
<b>Step 4</b>	<b>exit</b> <b>Example:</b> Device(config-if)# exit	Exits interface configuration mode.
<b>Step 5</b>	<b>interface vlan</b> <i>vlan-id</i> <b>Example:</b> Device(config)# interface vlan 32	Configures the VLAN ID.
<b>Step 6</b>	<b>ip address</b> <i>ip-address</i> <b>Example:</b> Device(config-if)# ip address 192.168.32.100 255.255.255.0	Configures the IP address for the interface.
<b>Step 7</b>	<b>no mop enabled</b> <b>Example:</b> Device(config-if)# no mop enabled	Disables the Maintenance Operation Protocol (MOP) for an interface.
<b>Step 8</b>	<b>no mop sysid</b> <b>Example:</b> Device(config-if)# no mop sysid	Disables the task of sending MOP periodic system ID messages.
<b>Step 9</b>	<b>exit</b> <b>Example:</b> Device(config-if)# exit	Exits the interface configuration mode.
<b>Step 10</b>	<b>ip dhcp-server</b> <i>ip-address</i> <b>Example:</b> Device(config)# ip dhcp-server 10.10.10.1	Specifies the target DHCP server parameters.
<b>Step 11</b>	<b>ip dhcp excluded-address</b> <i>ip-address</i> <b>Example:</b> Device(config)# ip dhcp excluded-address 192.168.32.1	Specifies the IP address that the DHCP server should not assign to DHCP clients.

	Command or Action	Purpose
<b>Step 12</b>	<b>ip dhcp excluded-address</b> <i>ip-address</i> <b>Example:</b> Device(config)# ip dhcp excluded-address 192.168.32.100	Specifies the IP address that the DHCP server should not assign to DHCP clients.
<b>Step 13</b>	<b>ip dhcp pool</b> <i>pool-name</i> <b>Example:</b> Device(config)# ip dhcp pool pool-vlan32	Configures the DHCP pool address.
<b>Step 14</b>	<b>network</b> <i>network-name mask-address</i> <b>Example:</b> Device(dhcp-config)# network 192.168.32.0 255.255.255.0	Specifies the network number in dotted-decimal notation along with the mask address.
<b>Step 15</b>	<b>default-router</b> <i>ip-address</i> <b>Example:</b> Device(dhcp-config)# default-router 192.168.32.1	Specifies the IP address of the default router for a DHCP client.
<b>Step 16</b>	<b>exit</b> <b>Example:</b> Device(dhcp-config)# exit	Exits DHCP configuration mode.
<b>Step 17</b>	<b>wireless profile policy</b> <i>profile-policy</i> <b>Example:</b> Device(config)# wireless profile policy default-policy-profile	Configures a WLAN policy profile and enters wireless policy configuration mode.
<b>Step 18</b>	<b>central association</b> <b>Example:</b> Device(config-wireless-policy)# central association	Configures central association for locally switched clients.
<b>Step 19</b>	<b>central dhcp</b> <b>Example:</b> Device(config-wireless-policy)# central dhcp	Configures central DHCP for locally switched clients.
<b>Step 20</b>	<b>central switching</b> <b>Example:</b> Device(config-wireless-policy)# central switching	Configures local switching.
<b>Step 21</b>	<b>description</b> <i>policy-profile-name</i> <b>Example:</b> Device(config-wireless-policy)# description "default policy profile"	Adds a description for the policy profile.

	Command or Action	Purpose
<b>Step 22</b>	<b>vlan <i>vlan-name</i></b> <b>Example:</b> Device(config-wireless-policy)# vlan 32	Assigns the profile policy to the VLAN.
<b>Step 23</b>	<b>no shutdown</b> <b>Example:</b> Device(config-wireless-policy)# no shutdown	Enables the profile policy.

## Verifying Internal DHCP Configuration

To verify the client binding, use the following command:

```
Device# show ip dhcp binding
```

```

Bindings from all pools not associated with VRF:
IP address      Client-ID/      Lease expiration      Type      State
Interface
                Hardware address/
                User name
192.168.32.3    0130.b49e.491a.53    Mar 23 2018 06:42 PM    Automatic    Active
Loopback0

```

To verify the DHCP relay statistics for wireless client, use the following command:

```
Device# show wireless dhcp relay statistics
```

```

DHCP Relay Statistics
-----

DHCP Server IP : 10.10.10.1

Message          Count
-----
DHCPDISCOVER    : 1
BOOTP FORWARD   : 137
BOOTP REPLY     : 0
DHCPOFFER      : 0
DHCPREQUEST     : 54
DHCPACK         : 0
DHCPNAK        : 0
DHCPDECLINE    : 0
DHCPRELEASE    : 0
DHCPINFORM     : 82

Tx/Rx Time :
-----
LastTxTime : 18:42:18
LastRxTime : 00:00:00

Drop Counter :
-----
TxDropCount : 0

```

To verify the DHCP packet punt statistics in CPP, use the following command:

```
Device# show platform hardware chassis active qfp feature wireless punt statistics
```

```
CPP Wireless Punt stats:
```

App Tag	Packet Count
-----	-----
CAPWAP_PKT_TYPE_DOT11_PROBE_REQ	14442
CAPWAP_PKT_TYPE_DOT11_MGMT	50
CAPWAP_PKT_TYPE_DOT11_IAPP	9447
CAPWAP_PKT_TYPE_DOT11_RFID	0
CAPWAP_PKT_TYPE_DOT11_RRM	0
CAPWAP_PKT_TYPE_DOT11_DOT1X	0
CAPWAP_PKT_TYPE_CAPWAP_KEEPALIVE	2191
CAPWAP_PKT_TYPE_MOBILITY_KEEPALIVE	0
CAPWAP_PKT_TYPE_CAPWAP_CNTRL	7034
CAPWAP_PKT_TYPE_CAPWAP_DATA	0
CAPWAP_PKT_TYPE_MOBILITY_CNTRL	0
WLS_SMD_WEBAUTH	0
SISF_PKT_TYPE_ARP	5292
SISF_PKT_TYPE_DHCP	140
SISF_PKT_TYPE_DHCP6	1213
SISF_PKT_TYPE_IPV6_ND	350
SISF_PKT_TYPE_DATA_GLEAN	44
SISF_PKT_TYPE_DATA_GLEAN_V6	51
SISF_PKT_TYPE_DHCP_RELAY	122
CAPWAP_PKT_TYPE_CAPWAP_RESERVED	0

## Additional References

### Related Documents

Related Topic	Document Title
System Management	<i>System Management Configuration Guide (Catalyst 3850 Switches)</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://cisco.com/go/mibs">http://cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

**Feature Information for DHCP for WLANs**

Feature Name	Release	Feature Information
DHCP functionality for WLAN	Cisco IOS XE 3.2SE	This feature was introduced.





## CHAPTER 163

# WLAN Security

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- [Finding Feature Information, on page 2907](#)
- [Prerequisites for Layer 2 Security, on page 2907](#)
- [Information About AAA Override, on page 2908](#)
- [How to Configure WLAN Security, on page 2908](#)
- [Additional References, on page 2913](#)
- [Feature Information about WLAN Layer 2 Security, on page 2913](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Layer 2 Security

WLANs with the same SSID must have unique Layer 2 security policies so that clients can make a WLAN selection based on the information advertised in beacon and probe responses. The available Layer 2 security policies are as follows:

- None (open WLAN)
- Static WEP or 802.1X



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**Note**

- Because static WEP and 802.1X are both advertised by the same bit in beacon and probe responses, they cannot be differentiated by clients. Therefore, they cannot both be used by multiple WLANs with the same SSID.
  - WLAN WEP is not supported in 1810w Access Point.
-

- WPA/WPA2

**Note**

- Although WPA and WPA2 cannot be used by multiple WLANs with the same SSID, you can configure two WLANs with the same SSID with WPA/TKIP with PSK and Wi-Fi Protected Access (WPA )/Temporal Key Integrity Protocol (TKIP) with 802.1X, or with WPA/TKIP with 802.1X or WPA/AES with 802.1X.
- A WLAN configured with TKIP support will not be enabled on an RM3000AC module.

**Related Topics**

- [Configuring Static WEP + 802.1X Layer 2 Security Parameters \(CLI\)](#), on page 2908
- [Configuring Static WEP Layer 2 Security Parameters \(CLI\)](#), on page 2909
- [Configuring WPA + WPA2 Layer 2 Security Parameters \(CLI\)](#), on page 2910
- [Configuring 802.1X Layer 2 Security Parameters \(CLI\)](#), on page 2912
- [Configuring Advanced WLAN Properties \(CLI\)](#), on page 2875
- [Information About AAA Override](#), on page 2908

## Information About AAA Override

The AAA Override option of a WLAN enables you to configure the WLAN for identity networking. It enables you to apply VLAN tagging, Quality of Service (QoS), and Access Control Lists (ACLs) to individual clients based on the returned RADIUS attributes from the AAA server.

**Related Topics**

- [Configuring Advanced WLAN Properties \(CLI\)](#), on page 2875
- [Prerequisites for Layer 2 Security](#), on page 2907

## How to Configure WLAN Security

### Configuring Static WEP + 802.1X Layer 2 Security Parameters (CLI)

**Before you begin**

You must have administrator privileges.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	configure terminal Example:	Enters global configuration mode.

	Command or Action	Purpose
	Device# <code>configure terminal</code>	
<b>Step 2</b>	<p><code>wlan profile-name</code></p> <p><b>Example:</b></p> <pre>Device# wlan test4</pre>	Enters WLAN configuration submode. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<p><code>security static-wep-key { authentication { open   sharedkey }   encryption { 104   40 } [ ascii   hex ] { 0   8 } } wep-key wep-key-index1-4</code></p> <p><b>Example:</b></p> <pre>Device(config-wlan)# security static-wep-key encryption 40 hex 0 test 2</pre>	<p>Configures static WEP security on a WLAN. The keywords and arguments are as follows:</p> <ul style="list-style-type: none"> <li>• <b>authentication</b>—Configures 802.11 authentication.</li> <li>• <b>encryption</b>—Sets the static WEP keys and indices.</li> <li>• <b>open</b>—Configures open system authentication.</li> <li>• <b>sharedkey</b>—Configures shared key authentication.</li> <li>• <b>104, 40</b>—Specifies the WEP key size.</li> <li>• <b>hex, ascii</b>—Specifies the input format of the key.</li> <li>• <i>wep-key-index</i> , <i>wep-key-index1-4</i>—Type of password that follows. A value of 0 indicates that an unencrypted password follows. A value of 8 indicates that an AES encrypted follows.</li> </ul>
<b>Step 4</b>	<p><code>end</code></p> <p><b>Example:</b></p> <pre>Device(config)# end</pre>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

**Related Topics**

[Prerequisites for Layer 2 Security](#), on page 2907

## Configuring Static WEP Layer 2 Security Parameters (CLI)

**Before you begin**

You must have administrator privileges.

**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan <i>profile-name</i></b>  <b>Example:</b> Device# <code>wlan test4</code>	Enters WLAN configuration submenu. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>security static-wep-key [authentication {open   shared}   encryption {104   40} {ascii   hex} [0   8]]</b>  <b>Example:</b> Device(config-wlan)# <code>security static-wep-key authentication open</code>	The keywords are as follows: <ul style="list-style-type: none"> <li>• <b>static-wep-key</b>—Configures Static WEP Key authentication.</li> <li>• <b>authentication</b>—Specifies the authentication type you can set. The values are open and shared.</li> <li>• <b>encryption</b>—Specifies the encryption type that you can set. The valid values are 104 and 40. 40-bit keys must contain 5 ASCII text characters or 10 hexadecimal characters. 104-bit keys must contain 13 ASCII text characters or 26 hexadecimal characters.</li> <li>• <b>ascii</b>—Specifies the key format as ASCII.</li> <li>• <b>hex</b>—Specifies the key format as HEX.</li> </ul>
<b>Step 4</b>	<b>end</b>  <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

**Related Topics**

[Prerequisites for Layer 2 Security](#), on page 2907

**Configuring WPA + WPA2 Layer 2 Security Parameters (CLI)**

**Note** The default security policy is WPA2.

**Before you begin**

You must have administrator privileges.

## Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan profile-name</b> <b>Example:</b> Device# <code>wlan test4</code>	Enters WLAN configuration submode. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>security wpa</b> <b>Example:</b> Device(config-wlan) # <code>security wpa</code>	Enables WPA.
<b>Step 4</b>	<b>security wpa wpa1</b> <b>Example:</b> Device(config-wlan) # <code>security wpa wpa1</code>	Enables WPA1.
<b>Step 5</b>	<b>security wpa wpa1 ciphers [aes   tkip]</b> <b>Example:</b> Device(config-wlan) # <code>security wpa wpa1 ciphers aes</code>	Specifies the WPA1 cipher. Choose one of the following encryption types: <ul style="list-style-type: none"> <li>• <b>aes</b>—Specifies WPA/AES support.</li> <li>• <b>tkip</b>—Specifies WPA/TKIP support.</li> </ul>
<b>Step 6</b>	<b>security wpa wpa2</b> <b>Example:</b> Device(config-wlan) # <code>security wpa</code>	Enables WPA2.
<b>Step 7</b>	<b>security wpa wpa2 ciphers [aes   tkip]</b> <b>Example:</b> Device(config-wlan) # <code>security wpa wpa2 ciphers tkip</code>	Configure WPA2 cipher. Choose one of the following encryption types: <ul style="list-style-type: none"> <li>• <b>aes</b>—Specifies WPA/AES support.</li> <li>• <b>tkip</b>—Specifies WPA/TKIP support.</li> </ul>
<b>Step 8</b>	<b>end</b> <b>Example:</b> Device(config) # <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Related Topics

[Prerequisites for Layer 2 Security](#), on page 2907

## Configuring 802.1X Layer 2 Security Parameters (CLI)

### Before you begin

You must have administrator privileges.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan <i>profile-name</i></b> <b>Example:</b> Device# <code>wlan test4</code>	Enters WLAN configuration submenu. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>security dot1x</b> <b>Example:</b> Device(config-wlan)# <code>security dot1x</code>	Specifies 802.1X security.
<b>Step 4</b>	<b>security [authentication-list <i>auth-list-name</i>   encryption {0   104   40}]</b> <b>Example:</b> Device(config-wlan)# <code>security encryption 104</code>	The keywords and arguments are as follows: <ul style="list-style-type: none"> <li>• <b>authentication-list</b>—Specifies the authentication list for IEEE 802.1X.</li> <li>• <b>encryption</b>—Specifies the length of the CKIP encryption key. The valid values are 0, 40, and 104. Zero (0) signifies no encryption. This is the default.</li> </ul> <p><b>Note</b> All keys in a WLAN must be of the same size.</p>
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

### Related Topics

[Prerequisites for Layer 2 Security](#), on page 2907

## Additional References

### Related Documents

Related Topic	Document Title
WLAN command reference	<i>WLAN Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>
Security configuration guide	<i>Security Configuration Guide (Catalyst 3850 Switches)</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information about WLAN Layer 2 Security

This table lists the features in this module and provides links to specific configuration information.

Feature Name	Release	Feature Information
WLAN Security functionality	Cisco IOS XE 3.2SE	This feature was introduced.





## CHAPTER 164

# Setting Client Count Per WLAN

- [Finding Feature Information, on page 2915](#)
- [Restrictions for Setting Client Count for WLANs, on page 2915](#)
- [Information About Setting the Client Count per WLAN, on page 2916](#)
- [How to Configure Client Count Per WLAN, on page 2916](#)
- [Monitoring Client Connections \(CLI\), on page 2918](#)
- [Additional References for Client Connections, on page 2919](#)
- [Feature Information about Client Connections Per WLAN, on page 2919](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Restrictions for Setting Client Count for WLANs

- When a WLAN has reached the limit on the maximum number of clients connected to it or an AP radio and a new client tries to join the WLAN, the client cannot connect to the WLAN until an existing client gets disconnected.
- Roaming clients are considered as new clients. The new client can connect to a WLAN, which has reached the maximum limit on the number of connected clients, only when an existing client gets disconnected.



**Note** For more information about the number of clients that are supported, see the product data sheet of your device.

### Related Topics

[Configuring Client Count per WLAN \(CLI\), on page 2916](#)

[Configuring Client Count Per AP Per WLAN \(CLI\)](#), on page 2917

[Configuring Client Count per AP Radio per WLAN \(CLI\)](#), on page 2917

[Information About Setting the Client Count per WLAN](#), on page 2916

## Information About Setting the Client Count per WLAN

You can set a limit to the number of clients that can connect to a WLAN, which is useful in scenarios where you have a limited number of clients that can connect to a device. For example, consider a scenario where the device can serve up to 256 clients on a WLAN and these clients can be shared between enterprise users (employees) and guest users. You can set a limit on the number of guest clients that can access a given WLAN. The number of clients that you can configure for each WLAN depends on the platform that you are using.

### Related Topics

[Configuring Client Count per WLAN \(CLI\)](#), on page 2916

[Configuring Client Count Per AP Per WLAN \(CLI\)](#), on page 2917

[Configuring Client Count per AP Radio per WLAN \(CLI\)](#), on page 2917

[Restrictions for Setting Client Count for WLANs](#), on page 2915

[Monitoring Client Connections \(CLI\)](#), on page 2918

## How to Configure Client Count Per WLAN

### Configuring Client Count per WLAN (CLI)

#### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan <i>profile-name</i></b>  <b>Example:</b> Device# <b>wlan test4</b>	Enters WLAN configuration submode. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>client association limit <i>limit</i></b>  <b>Example:</b> Device(config-wlan)# <b>client association limit 2000</b>	Configures the maximum number of client associations per WLAN. The range is 0 to 2000. A default value is 0 (no limit).
<b>Step 4</b>	<b>end</b>  <b>Example:</b> Device(wlan-config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-z</b> to exit global configuration mode.

**Related Topics**

- [Information About Setting the Client Count per WLAN](#), on page 2916
- [Restrictions for Setting Client Count for WLANs](#), on page 2915
- [Monitoring Client Connections \(CLI\)](#), on page 2918

## Configuring Client Count Per AP Per WLAN (CLI)

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan <i>profile-name</i></b>  <b>Example:</b> Device# <code>wlan test4</code>	Enters WLAN configuration submode. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>client association limit ap <i>ap-limit</i></b>  <b>Example:</b> Device(config-wlan)# <code>client association limit ap 250</code>	Configures the maximum number of clients per AP per WLAN. The range is 1 - 400.
<b>Step 4</b>	<b>end</b>  <b>Example:</b> Device(wlan-config)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-z</b> to exit global configuration mode.

**Related Topics**

- [Information About Setting the Client Count per WLAN](#), on page 2916
- [Restrictions for Setting Client Count for WLANs](#), on page 2915
- [Monitoring Client Connections \(CLI\)](#), on page 2918

## Configuring Client Count per AP Radio per WLAN (CLI)

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan <i>profile-name</i></b>  <b>Example:</b> Device# <code>wlan test4</code>	Enters WLAN configuration submode. The <i>profile-name</i> is the profile name of the configured WLAN.

	Command or Action	Purpose
<b>Step 3</b>	<b>client association limit radio</b> <i>max-client-connections</i>  <b>Example:</b> Device(config-wlan)# <b>client association</b> <b>limit radio 180</b>	Configures the maximum number of client connections per AP radio per WLAN. The range is 0 - 200 for the a, b, and g radios.
<b>Step 4</b>	<b>end</b>  <b>Example:</b> Device(config-wlan)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-z</b> to exit global configuration mode.

**Related Topics**

- [Information About Setting the Client Count per WLAN](#), on page 2916
- [Restrictions for Setting Client Count for WLANs](#), on page 2915
- [Monitoring Client Connections \(CLI\)](#), on page 2918

## Monitoring Client Connections (CLI)

The following commands can be used to monitor client connections on the device:

Command	Description
<b>show wlan name</b> <i>wlan-name</i>	Displays the WLAN properties. Here is an example:  <pre> . . . . . Max Associated Clients per WLAN                :0 Max Associated Clients per AP per WLAN          :0 Max Associated Clients per AP Radio per WLAN   :0 . . . . .           </pre>
<b>show wlan id</b> <i>wlan-id</i>	Displays the WLAN properties. here is an example:  <pre> . . . . . Max Associated Clients per WLAN                :0 Max Associated Clients per AP per WLAN          :0 Max Associated Clients per AP Radio per WLAN   :0 . . . . .           </pre>

**Related Topics**

- [Configuring Client Count per WLAN \(CLI\)](#), on page 2916
- [Configuring Client Count Per AP Per WLAN \(CLI\)](#), on page 2917
- [Configuring Client Count per AP Radio per WLAN \(CLI\)](#), on page 2917
- [Information About Setting the Client Count per WLAN](#), on page 2916

## Additional References for Client Connections

### Related Documents

Related Topic	Document Title
WLAN Command References	<i>WLAN Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### MIBs

MIB	MIBs Link
All MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information about Client Connections Per WLAN

This table lists the features in this module and provides links to specific configuration information:

Feature Name	Release	Feature Information
Client Connections Per WLAN, Per AP, and per AP Radio	Cisco IOS XE 3.3SE	This feature was introduced.





## CHAPTER 165

### 802.11w

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- [Finding Feature Information](#), on page 2921
- [Prerequisites for 802.11w](#), on page 2921
- [Restrictions for 802.11w](#), on page 2922
- [Information About 802.11w](#), on page 2922
- [How to Configure 802.11w](#), on page 2923
- [Disabling 802.11w \(CLI\)](#), on page 2924
- [Monitoring 802.11w \(CLI\)](#), on page 2925
- [Additional References for 802.11w](#), on page 2926
- [Feature Information for 802.11w](#), on page 2927

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for 802.11w

- To configure 802.11w feature for optional and mandatory, you must have WPA and AKM configured.



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**Note** The RNS (Robust Secure Network) IE must be enabled with an AES Cipher.

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- To configure 802.11w as mandatory, you must enable PMF AKM in addition to WPA AKM.

### Related Topics

- [Configuring 802.11w \(CLI\)](#), on page 2923
- [Disabling 802.11w \(CLI\)](#), on page 2924

[Information About 802.11w](#), on page 2922

## Restrictions for 802.11w

- 802.11w cannot be applied on an open WLAN, WEP-encrypted WLAN, or a TKIP-encrypted WLAN.
- The WLAN on which 802.11w is configured must have either WPA2-PSK or WPA2-802.1x security configured.

### Related Topics

[Configuring 802.11w \(CLI\)](#), on page 2923

[Disabling 802.11w \(CLI\)](#), on page 2924

[Information About 802.11w](#), on page 2922

## Information About 802.11w

Wi-Fi is a broadcast medium that enables any device to eavesdrop and participate either as a legitimate or rogue device. Control and management frames such as authentication/deauthentication, association/disassociation, beacons, and probes are used by wireless clients to select an AP and to initiate a session for network services.

Unlike data traffic which can be encrypted to provide a level of confidentiality, these frames must be heard and understood by all clients and therefore must be transmitted as open or unencrypted. While these frames cannot be encrypted, they must be protected from forgery to protect the wireless medium from attacks. For example, an attacker could spoof management frames from an AP to tear down a session between a client and AP.

The 802.11w protocol applies only to a set of robust management frames that are protected by the Management Frame Protection (PMF) service. These include Disassociation, Deauthentication, and Robust Action frames.

Management frames that are considered as robust action and therefore protected are the following:

- Spectrum Management
- QoS
- Block Ack
- SA Query
- Vendor-specific Protected

When 802.11w is implemented in the wireless medium, the following occur:

- Client protection is added by the AP adding cryptographic protection (by including the MIC information element) to deauthentication and disassociation frames preventing them from being spoofed in a DOS attack.
- Infrastructure protection is added by adding a Security Association (SA) teardown protection mechanism consisting of an Association Comeback Time and an SA-Query procedure preventing spoofed association request from disconnecting an already connected client.



**Related Topics**

[Configuring 802.11w \(CLI\)](#), on page 2923

[Disabling 802.11w \(CLI\)](#), on page 2924

[Prerequisites for 802.11w](#), on page 2921

[Restrictions for 802.11w](#), on page 2922

[Monitoring 802.11w \(CLI\)](#), on page 2925

# How to Configure 802.11w

## Configuring 802.11w (CLI)

**Before you begin**

WPA and AKM must be configured.

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan profile-name</b>  <b>Example:</b> Device# <code>wlan test4</code>	Enters WLAN configuration submode. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>shutdown</b>  <b>Example:</b> Device <code>shutdown</code>	Shutdown the WLAN before configuring the PMF.
<b>Step 4</b>	<b>security pmf {association-check association-comeback-time-in-seconds   mandatory   optional   saquery saquery-time-in-milliseconds}</b>  <b>Example:</b> Device(config-wlan) # <code>security pmf saquery-retry-time 200</code>	Configures the PMF parameters with the following options: <ul style="list-style-type: none"> <li>• <b>association-comeback</b>—Configures the 802.11w association comeback time. The range is from 1 to 20 seconds.</li> <li>• <b>mandatory</b>—Requires clients to negotiate 802.11w PMF protection on a WLAN.</li> <li>• <b>optional</b>—Enables 802.11w PMF protection on a WLAN.</li> <li>• <b>saquery</b>—Time interval identified in milliseconds before which the SA query response is expected. If the device does</li> </ul>

	Command or Action	Purpose
		<p>not get a response, another SQ query is tried.</p> <p>The range is from 100 to 500 ms. The value must be specified in multiples of 100 milliseconds.</p>
<b>Step 5</b>	<b>no shutdown</b> <b>Example:</b> Device <code>no shutdown</code>	Restart the WLAN for the changes to take effect.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device (config-wlan) # <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-z</b> to exit global configuration mode.

**Related Topics**

[Information About 802.11w](#), on page 2922

[Prerequisites for 802.11w](#), on page 2921

[Restrictions for 802.11w](#), on page 2922

[Monitoring 802.11w \(CLI\)](#), on page 2925

## Disabling 802.11w (CLI)

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan <i>profile-name</i></b> <b>Example:</b> Device# <code>wlan test4</code>	Enters WLAN configuration submenu. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>shutdown</b> <b>Example:</b> Device <code>shutdown</code>	Shutdown the WLAN before configuring the PMF.
<b>Step 4</b>	<b>no security pmf [association-comeback            association-check-comback-interval-seconds              mandatory   optional   saquery            saquery-time-interval-milliseconds]</b> <b>Example:</b>	Disables PMF on the WLAN. The following attributes are available: <ul style="list-style-type: none"> <li>• <b>association-comeback</b>—Disables the 802.11w association comeback time.</li> </ul>

	Command or Action	Purpose
	Device (config-wlan) # <b>no security pmf</b>	<ul style="list-style-type: none"> <li>• <b>mandatory</b>—Disables clients to negotiate 802.11w PMF protection on a WLAN.</li> <li>• <b>optional</b>—Disables 802.11w PMF protection on a WLAN.</li> <li>• <b>saquery</b>—Time interval identified in the association response to an already associated client before the association can be tried again. This time interval checks if the client is a real client and not a rogue client during the association comeback time. If the client does not respond within this time, the client association is deleted from the device</li> </ul> <p>The range is from 100 to 500 ms. The value must be specified in multiples of 100 milliseconds.</p>
<b>Step 5</b>	<b>no shutdown</b> <b>Example:</b> Device <b>no shutdown</b>	Restart the WLAN for the changes to take effect.
<b>Step 6</b>	<b>end</b> <b>Example:</b> Device (config-wlan) # <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-z</b> to exit global configuration mode.

#### Related Topics

[Information About 802.11w](#), on page 2922

[Prerequisites for 802.11w](#), on page 2921

[Restrictions for 802.11w](#), on page 2922

[Monitoring 802.11w \(CLI\)](#), on page 2925

## Monitoring 802.11w (CLI)

The following command can be used to monitor 802.11w:

Command	Description
<code>show wlan name <i>wlan-profile-name</i></code>	<p>Displays the WLAN parameters on the WLAN. The PMF parameters are displayed. Here is an example:</p> <pre> . . . . . . . . Auth Key Management   802.1x                               : Disabled    PSK                                   : Enabled    CCKM                                  : Disabled    FT dot1x                              : Disabled    FT PSK                                : Disabled    PMF dot1x                             : Disabled    PMF PSK                                : Enabled    FT Support                             : Disabled        FT Reassociation Timeout           : 20       FT Over-The-DS mode                : Disabled    PMF Support                             : Required        PMF Association Comeback Timeout   : 9       PMF SA Query Time                  : 200 . . . . . . . . </pre>

**Related Topics**

[Configuring 802.11w \(CLI\)](#), on page 2923

[Disabling 802.11w \(CLI\)](#), on page 2924

[Information About 802.11w](#), on page 2922

## Additional References for 802.11w

**Related Documents**

Related Topic	Document Title
WLAN Command Reference	<i>WLAN Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>
WLAN Security	<i>Configuring WLAN Security</i> chapter in this book.

**Error Message Decoder**

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**Standards and RFCs**

Standard/RFC	Title
802.11w	IEEE 802.11w Protected Management Frames

**MIBs**

MIB	MIBs Link
All supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for 802.11w

This table lists the features in this module and provides links to specific configuration information:

Feature Name	Release	Feature Information
802.11w	Cisco IOS XE 3.3SE	This feature was introduced.





## CHAPTER 166

# Configuring Wi-Fi Direct Client Policy

- [Finding Feature Information, on page 2929](#)
- [Restrictions for the Wi-Fi Direct Client Policy, on page 2929](#)
- [Information About the Wi-Fi Direct Client Policy, on page 2930](#)
- [How to Configure Wi-Fi Direct Client Policy, on page 2930](#)
- [Additional References for Wi-Fi Direct Client Policy, on page 2932](#)
- [Feature Information about Wi-Fi Direct Client Policy, on page 2933](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Restrictions for the Wi-Fi Direct Client Policy

- Wi-Fi Direct Client Policy is applicable to WLANs that have APs in local mode only.
- Cisco APs in FlexConnect mode (even in central authentication and central switching) is not supported.
- We do not recommend enabling this feature in a mixed AP mode deployment (some APs in FlexConnect mode and some APs in local mode). Such types of deployment is not supported or tested in FlexConnect mode.
- If WLAN applied client policy is invalid, the client is excluded with the exclusion reason being 'Client QoS Policy failure'.

# Information About the Wi-Fi Direct Client Policy

Devices that are Wi-Fi Direct capable can connect directly to each other quickly and conveniently to do tasks such as printing, synchronization, and sharing of data. Wi-Fi Direct devices may associate with multiple peer-to-peer (P2P) devices and with infrastructure wireless LANs (WLANs) concurrently. You can use the device to configure the Wi-Fi Direct Client Policy, on a per WLAN basis, where you can allow or disallow association of Wi-Fi devices with infrastructure WLANs, or disable Wi-Fi Direct Client Policy altogether for WLANs.

## Related Topics

[Configuring the Wi-Fi Direct Client Policy \(CLI\)](#), on page 2930

[Disabling Wi-Fi Direct Client Policy \(CLI\)](#), on page 2931

[Monitoring Wi-Fi Direct Client Policy \(CLI\)](#), on page 2932

# How to Configure Wi-Fi Direct Client Policy

## Configuring the Wi-Fi Direct Client Policy (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan <i>profile-name</i></b> <b>Example:</b> Device# <code>wlan test4</code>	Enters WLAN configuration submode. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>wifidirect policy {permit   deny }</b> <b>Example:</b> Device(config-wlan)# <code>wifidirect policy permit</code>	Configures the Wi-Fi Direct client policy on the WLAN using one of the following: <ul style="list-style-type: none"> <li>• <b>permit</b>—Enables Wi-Fi Direct clients to associate with the WLAN.</li> <li>• <b>deny</b>—When the Wi-Fi Direct policy is configured as "deny," the device permits or denies Wi-Fi Direct devices based on the device capabilities. A Wi-Fi Direct device reports these capabilities in its association request to the device and these are based on the Wi-Fi capabilities of the device. These include:               <ul style="list-style-type: none"> <li>• Concurrent operation</li> <li>• Cross connection</li> </ul> </li> </ul>



	Command or Action	Purpose
		<p><b>Note</b> The command <b>no wifidirect policy</b> ignores the client's Wi-Fi direct status. Additionally, the access point also does not advertise any beacons and probes. Effectively, the <b>no</b> form of the command disables the Wi-Fi direct feature on the WLAN.</p> <p>If the Wi-Fi device supports either concurrent operations or cross connections or both, the client association is denied. The client can associate if the device does not support concurrent operations and cross connections.</p>
<b>Step 4</b>	<p><b>end</b></p> <p><b>Example:</b></p> <pre>Device(config-wlan)# end</pre>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-z</b> to exit global configuration mode.

**Related Topics**

[Information About the Wi-Fi Direct Client Policy](#), on page 2930

[Monitoring Wi-Fi Direct Client Policy \(CLI\)](#), on page 2932

## Disabling Wi-Fi Direct Client Policy (CLI)

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Device# configure terminal</pre>	Enters global configuration mode.
<b>Step 2</b>	<p><b>wlan <i>profile-name</i></b></p> <p><b>Example:</b></p> <pre>Device# wlan test4</pre>	Enters WLAN configuration submenu. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<p><b>no wifidirect policy</b></p> <p><b>Example:</b></p> <pre>Device(config)# no wifidirect policy</pre>	Ignores the Wi-Fi Direct status of clients thereby allowing Wi-Fi Direct clients to associate.

	Command or Action	Purpose
<b>Step 4</b>	<b>end</b>  <b>Example:</b> Device(config-wlan)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-z</b> to exit global configuration mode.

**Related Topics**

[Information About the Wi-Fi Direct Client Policy](#), on page 2930

[Monitoring Wi-Fi Direct Client Policy \(CLI\)](#), on page 2932

## Monitoring Wi-Fi Direct Client Policy (CLI)

The following commands can be used to monitor Wi-Fi Direct Client Policy:

Command	Description
<b>show wireless client wifidirect stats</b>	Displays the total number of clients associated and the number of association requests rejected if the Wi-Fi Direct Client Policy is enabled.
<b>show wlan summary</b>	Displays status of the Wi-Fi Direct on the WLAN.
<b>show wireless cli mac-address</b> <i>mac-address</i>	Displays the detail information of a client.

**Related Topics**

[Configuring the Wi-Fi Direct Client Policy \(CLI\)](#), on page 2930

[Disabling Wi-Fi Direct Client Policy \(CLI\)](#), on page 2931

[Information About the Wi-Fi Direct Client Policy](#), on page 2930

## Additional References for Wi-Fi Direct Client Policy

**Related Documents**

Related Topic	Document Title
WLAN Command reference	<i>WLAN Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>

**Error Message Decoder**

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

**MIBs**

MIB	MIBs Link
All Supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information about Wi-Fi Direct Client Policy

Feature Name	Release	Feature Information
Wi-Fi Direct Feature	Cisco IOS XE 3.3SE	This feature was introduced.





## CHAPTER 167

# Configuring 802.11r BSS Fast Transition

- [Finding Feature Information, on page 2935](#)
- [Restrictions for 802.11r Fast Transition, on page 2935](#)
- [Information About 802.11r Fast Transition, on page 2936](#)
- [How to Configure 802.11r Fast Transition, on page 2938](#)
- [Additional References for 802.11r Fast Transition, on page 2944](#)
- [Feature Information for 802.11r Fast Transition, on page 2945](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Restrictions for 802.11r Fast Transition

- EAP LEAP method is not supported.
- TSpec is not supported for 802.11r fast roaming. Therefore, RIC IE handling is not supported.
- If WAN link latency exists, fast roaming is also delayed. Voice or data maximum latency should be verified. The Cisco WLC handles 802.11r Fast Transition authentication request during roaming for both Over-the-Air and Over-the-DS methods.
- This feature is supported on open and WPA2 configured WLANs.
- Legacy clients cannot associate with a WLAN that has 802.11r enabled if the driver of the supplicant that is responsible for parsing the Robust Security Network Information Exchange (RSN IE) is old and not aware of the additional AKM suites in the IE. Due to this limitation, clients cannot send association requests to WLANs. These clients, however, can still associate with non-802.11r WLANs. Clients that are 802.11r capable can associate as 802.11i clients on WLANs that have both 802.11i and 802.11r Authentication Key Management Suites enabled.

The workaround is to enable or upgrade the driver of the legacy clients to work with the new 802.11r AKMs, after which the legacy clients can successfully associate with 802.11r enabled WLANs.

Another workaround is to have two SSIDs with the same name but with different security settings (FT and non-FT).

- Fast Transition resource request protocol is not supported because clients do not support this protocol. Also, the resource request protocol is an optional protocol.
- To avoid any Denial of Service (DoS) attack, each Cisco WLC allows a maximum of three Fast Transition handshakes with different APs.
- Non-802.11r capable devices will not be able to associate with FT-enabled WLAN.
- 802.11r FT + PMF is not recommended.
- 802.11r FT Over-the-Air roaming is recommended for FlexConnect deployments.
- In a default FlexGroup scenario, fast roaming is not supported.
- As part of a fix for [CSCvk64674](#), Adaptive mode for 802.11r Fast Transition is not supported for open WLANs. That is, if you choose Layer 2 security as *None* for a WLAN, ensure that you disable the Adaptive mode for 802.11r Fast Transition; else, WLAN cannot be enabled.

#### Related Topics

[Configuring 802.11r Fast Transition in an Open WLAN \(CLI\)](#), on page 2938

[Disabling 802.11r Fast Transition \(CLI\)](#), on page 2942

[Configuring 802.11r BSS Fast Transition on a Dot1x Security Enabled WLAN \(CLI\)](#), on page 2940

[Configuring 802.11r Fast Transition on a PSK Security Enabled WLAN \(CLI\)](#), on page 2941

[Information About 802.11r Fast Transition](#), on page 2936

## Information About 802.11r Fast Transition

802.11r, which is the IEEE standard for fast roaming, introduces a new concept of roaming where the initial handshake with the new AP is done even before the client roams to the target AP, which is called Fast Transition (FT). The initial handshake allows the client and APs to do the Pairwise Transient Key (PTK) calculation in advance. These PTK keys are applied to the client and AP after the client does the reassociation request or response exchange with new target AP.

802.11r provides two methods of roaming:

- Over-the-Air
- Over-the-DS (Distribution System)

The FT key hierarchy is designed to allow clients to make fast BSS transitions between APs without requiring reauthentication at every AP. WLAN configuration contains a new Authenticated Key Management (AKM) type called FT (Fast Transition).

From Release 3E, you can create an 802.11r WLAN that is also an WPAv2 WLAN. In earlier releases, you had to create separate WLANs for 802.11r and for normal security. Non-802.11r clients can now join 802.11r-enabled WLANs as the 802.11r WLANs can accept non-802.11r associations. If clients do not support mixed mode or 802.11r join, they can join non-802.11r WLANs. When you configure FT PSK and later define PSK, clients that can join only PSK can now join the WLAN in mixed mode.

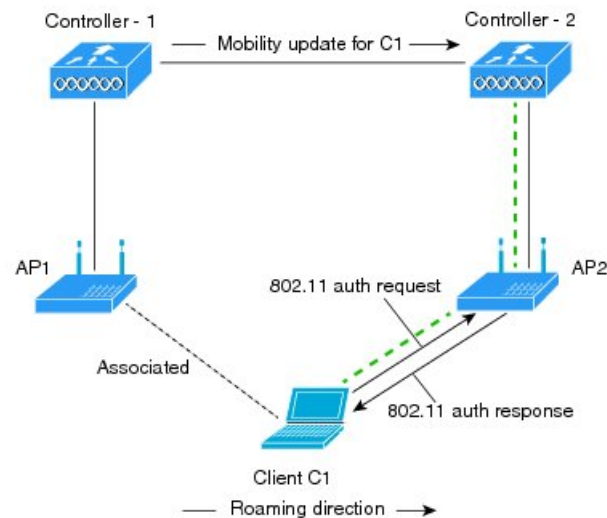
### How a Client Roams

For a client to move from its current AP to a target AP using the FT protocols, the message exchanges are performed using one of the following two methods:

- Over-the-Air—The client communicates directly with the target AP using IEEE 802.11 authentication with the FT authentication algorithm.
- Over-the-DS—The client communicates with the target AP through the current AP. The communication between the client and the target AP is carried in FT action frames between the client and the current AP and is then sent through the device.

**Figure 153: Message Exchanges when Over the Air client roaming is configured**

This figure shows the sequence of message exchanges that occur when Over the Air client roaming is configured.

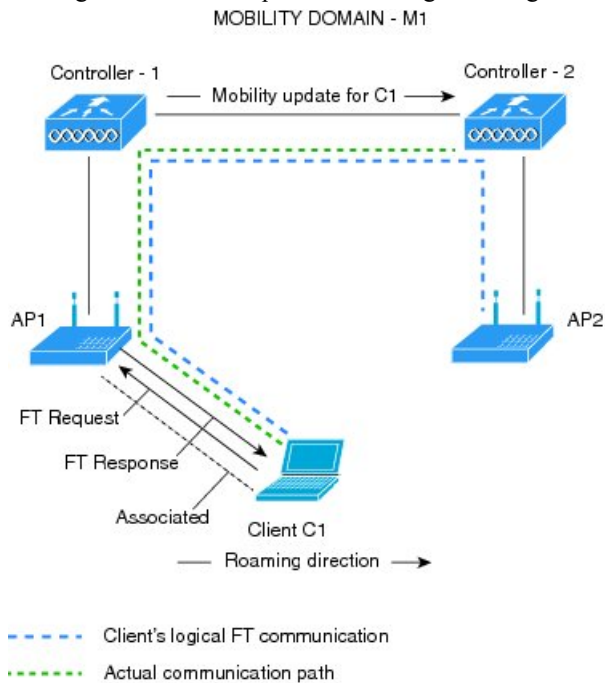


configured. . . . . Actual communication path

351714

Figure 154: Message Exchanges when Over the DS client roaming is configured

This figure shows the sequence of message exchanges that occur when Over the DS client roaming is configured.



### Related Topics

[Configuring 802.11r Fast Transition in an Open WLAN \(CLI\)](#), on page 2938

[Disabling 802.11r Fast Transition \(CLI\)](#), on page 2942

[Configuring 802.11r BSS Fast Transition on a Dot1x Security Enabled WLAN \(CLI\)](#), on page 2940

[Configuring 802.11r Fast Transition on a PSK Security Enabled WLAN \(CLI\)](#), on page 2941

[Monitoring 802.11r Fast Transition \(CLI\)](#), on page 2943

[Restrictions for 802.11r Fast Transition](#), on page 2935

# How to Configure 802.11r Fast Transition

## Configuring 802.11r Fast Transition in an Open WLAN (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.



	Command or Action	Purpose
<b>Step 2</b>	<b>wlan</b> <i>profile-name</i> <b>Example:</b> Device# <b>wlan test4</b>	Enters WLAN configuration submode. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>client vlan</b> <i>vlan-id</i> <b>Example:</b> Device (config-wlan) # <b>client vlan 0120</b>	Associate the client VLAN to the WLAN.
<b>Step 4</b>	<b>no security wpa</b> <b>Example:</b> Device (config-wlan) # <b>no security wpa</b>	Disable WPA security.
<b>Step 5</b>	<b>no security wpa akm dot1x</b> <b>Example:</b> Device (config-wlan) # <b>no security wpa akm dot1x</b>	Disable security AKM for dot1x.
<b>Step 6</b>	<b>no security wpa wpa2</b> <b>Example:</b> Device (config-wlan) # <b>no security wpa wpa2</b>	Disables WPA2 security.
<b>Step 7</b>	<b>no wpa wpa2 ciphers aes</b> <b>Example:</b> Device (config-wlan) # <b>no security wpa wpa2 ciphers aes</b>	Disables WPA2 ciphers for AES.
<b>Step 8</b>	<b>security ft</b> <b>Example:</b> Device (config-wlan) # <b>security ft</b>	Specifies the 802.11r fast transition parameters.
<b>Step 9</b>	<b>no shutdown</b> <b>Example:</b> Device (config-wlan) # <b>shutdown</b>	Shutdown the WLAN.
<b>Step 10</b>	<b>end</b> <b>Example:</b> Device (config-wlan) # <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-z</b> to exit global configuration mode

**Related Topics**

[Information About 802.11r Fast Transition](#), on page 2936

[Monitoring 802.11r Fast Transition \(CLI\)](#), on page 2943

[Restrictions for 802.11r Fast Transition](#), on page 2935

## Configuring 802.11r BSS Fast Transition on a Dot1x Security Enabled WLAN (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan <i>profile-name</i></b> <b>Example:</b> Device# <code>wlan test4</code>	Enters WLAN configuration submode. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>client vlan <i>vlan-name</i></b> <b>Example:</b> Device(config-wlan)# <code>client vlan 0120</code>	Associate the client VLAN to this WLAN.
<b>Step 4</b>	<b>local-auth <i>local-auth-profile-eap</i></b> <b>Example:</b> Device(config-wlan)# <code>local-auth</code>	Enable the local auth EAP profile.
<b>Step 5</b>	<b>security dot1x authentication-list default</b> <b>Example:</b> Device(config-wlan)# <code>security dot1x authentication-list default</code>	Enable security authentication list for dot1x security. The configuration is similar for any dot1x security WLAN.
<b>Step 6</b>	<b>security ft</b> <b>Example:</b> Device(config-wlan)# <code>security ft</code>	Enables 802.11r Fast Transition on this WLAN.
<b>Step 7</b>	<b>security wpa akm ft dot1x</b> <b>Example:</b> Device(config-wlan)# <code>security wpa akm ft dot1x</code>	Enables 802.1x security on the WLAN.
<b>Step 8</b>	<b>no shutdown</b> <b>Example:</b> Device(config-wlan)# <code>no shutdown</code>	Enable the WLAN.
<b>Step 9</b>	<b>end</b> <b>Example:</b> Device(config-wlan)# <code>end</code>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-z</b> to exit global configuration mode

**Related Topics**

[Information About 802.11r Fast Transition](#), on page 2936

[Monitoring 802.11r Fast Transition \(CLI\)](#), on page 2943

[Restrictions for 802.11r Fast Transition](#), on page 2935

**Configuring 802.11r Fast Transition on a PSK Security Enabled WLAN (CLI)****Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan <i>profile-name</i></b>  <b>Example:</b> Device# <code>wlan test4</code>	Enters WLAN configuration submode. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>client vlan <i>vlan-name</i></b>  <b>Example:</b> Device(config-wlan)# <code>client vlan 0120</code>	Associates the client VLAN to this WLAN.
<b>Step 4</b>	<b>no security wpa akm dot1x</b>  <b>Example:</b> Device(config-wlan)# <code>no security wpa akm dot1x</code>	Disables security AKM for dot1x.
<b>Step 5</b>	<b>security wpa akm ft psk</b>  <b>Example:</b> Device(config-wlan)# <code>security wpa akm ft psk</code>	Configures FT PSK support.
<b>Step 6</b>	<b>security wpa akm psk set-key {ascii {0   8}   hex {0   8}}</b>  <b>Example:</b> Device(config-wlan)# <code>security wpa akm psk set-key ascii 0 test</code>	Configures PSK AKM shared key.
<b>Step 7</b>	<b>security ft</b>  <b>Example:</b> Device(config-wlan)# <code>security ft</code>	Configures 802.11r Fast Transition.
<b>Step 8</b>	<b>no shutdown</b>  <b>Example:</b> Device(config-wlan)# <code>no shutdown</code>	Enables the WLAN.

	Command or Action	Purpose
<b>Step 9</b>	<b>end</b>  <b>Example:</b> Device(config-wlan)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-z</b> to exit global configuration mode

**Related Topics**

[Information About 802.11r Fast Transition](#), on page 2936

[Monitoring 802.11r Fast Transition \(CLI\)](#), on page 2943

[Restrictions for 802.11r Fast Transition](#), on page 2935

## Disabling 802.11r Fast Transition (CLI)

**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b>  <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>wlan profile-name</b>  <b>Example:</b> Device# <b>wlan test4</b>	Enters WLAN configuration submenu. The <i>profile-name</i> is the profile name of the configured WLAN.
<b>Step 3</b>	<b>no security ft [over-the-ds   reassociation-timeout timeout-in-seconds]</b>  <b>Example:</b> Device(config-wlan)# <b>no security ft over-the-ds</b>	Disables 802.11r Fast Transition on the WLAN.  <b>Note</b> Disabling 802.11r Fast Transition for over the data source enables over the air fast transition.
<b>Step 4</b>	<b>end</b>  <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

**Related Topics**

[Information About 802.11r Fast Transition](#), on page 2936

[Monitoring 802.11r Fast Transition \(CLI\)](#), on page 2943

[Restrictions for 802.11r Fast Transition](#), on page 2935

## Monitoring 802.11r Fast Transition (GUI)

You can view the Authentication Key Management details of a client.

Choose **Monitor > Client**. The Clients page appears. Click the corresponding client to view the client details. In the **General** tab, you can view the Authentication Key Management for the client such as FT, PSK, 802.1x,

CCKM, 802.1x + CCKM. If the AKM is for 802.11r mixed mode, then FT-802.1x, FT-802.1x-CCKM, or FT-PSK appears.

## Monitoring 802.11r Fast Transition (CLI)

The following command can be used to monitor 802.11r Fast Transition:

Command	Description
<b>show wlan name</b> <i>wlan-name</i>	Displays a summary of the configured parameters on the WLAN.
<b>show wireless client mac-address</b> <i>mac-address</i>	<p>Displays the summary of the 802.11r authentication key management configuration on a client.</p> <pre> . . . . . . Client Capabilities   CF Pollable : Not implemented   CF Poll Request : Not implemented   Short Preamble : Not implemented   PBCC : Not implemented   Channel Agility : Not implemented   Listen Interval : 15   Fast BSS Transition : Implemented Fast BSS Transition Details : Client Statistics:   Number of Bytes Received : 9019   Number of Bytes Sent : 3765   Number of Packets Received : 130   Number of Packets Sent : 36   Number of EAP Id Request Msg Timeouts : 0   Number of EAP Request Msg Timeouts : 0   Number of EAP Key Msg Timeouts : 0   Number of Data Retries : 1   Number of RTS Retries : 0   Number of Duplicate Received Packets : 1   Number of Decrypt Failed Packets : 0   Number of Mic Failed Packets : 0   Number of Mic Missing Packets : 0   Number of Policy Errors : 0   Radio Signal Strength Indicator : -48 dBm   Signal to Noise Ratio : 40 dB . . . . . .  If the AKM for the client is 802.11r mixed mode, the following information appears in the output:  . . . . . . Authentication Key Management : FT-PSK . . . . . . </pre>

### Related Topics

[Configuring 802.11r Fast Transition in an Open WLAN \(CLI\)](#), on page 2938

[Disabling 802.11r Fast Transition \(CLI\)](#), on page 2942

[Configuring 802.11r BSS Fast Transition on a Dot1x Security Enabled WLAN \(CLI\)](#), on page 2940

[Configuring 802.11r Fast Transition on a PSK Security Enabled WLAN \(CLI\)](#), on page 2941

[Information About 802.11r Fast Transition](#), on page 2936

## Additional References for 802.11r Fast Transition

### Related Documents

Related Topic	Document Title
WLAN Command Reference.	<i>WLAN Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### Standards and RFCs

Standard/RFC	Title
802.11r from IEEE.	IEEE Standard for 802.11r

### MIBs

MIB	MIBs Link
All MIBs supported for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for 802.11r Fast Transition

This table lists the features in this module and provides links to specific configuration information:

Feature Name	Release	Feature Information
802.11r Fast Transition	Cisco IOS XE 3.3SE	This feature was introduced.







## CHAPTER 168

# Assisted Roaming

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- [Finding Feature Information, on page 2947](#)
- [Information About Assisted Roaming, on page 2947](#)
- [Restrictions for Assisted Roaming, on page 2948](#)
- [How to Configure Assisted Roaming, on page 2949](#)
- [Verifying Assisted Roaming, on page 2950](#)
- [Configuration Examples for Assisted Roaming, on page 2950](#)
- [Additional References for Assisted Roaming, on page 2951](#)
- [Feature History and Information For Performing Assisted Roaming Configuration, on page 2952](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Information About Assisted Roaming

The 802.11k standard allows clients to request neighbor reports containing information about known neighbor access points that are candidates for a service set transition. The use of the 802.11k neighbor list can limit the need for active and passive scanning.

The assisted roaming feature is based on an intelligent and client optimized neighbor list.

Unlike the Cisco Client Extension (CCX) neighbor list, the 802.11k neighbor list is generated dynamically on-demand and is not maintained on the device. The 802.11k neighbor list is based on the location of the clients without requiring the mobility services engine (MSE). Two clients on the same device but different APs can have different neighbor lists delivered depending on their individual relationship with the surrounding APs.

By default, the neighbor list contains only neighbors in the same band with which the client is associated. However, a switch exists that allows 802.11k to return neighbors in both bands.

Clients send requests for neighbor lists only after associating with the APs that advertize the RRM (Radio Resource Management) capability information element (IE) in the beacon. The neighbor list includes information about BSSID, channel, and operation details of the neighboring radios.

### Assembling and Optimizing the Neighbor List

When the device receives a request for an 802.11k neighbor list, the following occurs:

1. The device searches the RRM neighbor table for a list of neighbors on the same band as the AP with which the client is currently associated with.
2. The device checks the neighbors according to the RSSI (Received Signal Strength Indication) between the APs, the current location of the present AP, the floor information of the neighboring AP from Cisco Prime Infrastructure, and roaming history information on the device to reduce the list of neighbors to six per band. The list is optimized for APs on the same floor.

### Assisted Roaming for Non-802.11k Clients

It is also possible to optimize roaming for non-802.11k clients. You can generate a prediction neighbor list for each client without the client requiring to send an 802.11k neighbor list request. When this is enabled on a WLAN, after each successful client association/reassociation, the same neighbor list optimization is applied on the non-802.11k client to generate the neighbor list and store the list in the mobile station software data structure. Clients at different locations have different lists because the client probes are seen with different RSSI values by different neighbors. Because clients usually probe before any association or reassociation, this list is constructed with the most updated probe data and predicts the next AP that the client is likely to roam to.

We discourage clients from roaming to those less desirable neighbors by denying association if the association request to an AP does not match the entries on the stored prediction neighbor list.

Similar to aggressive load balancing, there is a switch to turn on the assisted roaming feature both on a per-WLAN basis and globally. The following options are available:

- Denial count—Maximum number of times a client is refused association.
- Prediction threshold—Minimum number of entries required in the prediction list for the assisted roaming feature to be activated.

Because both load balancing and assisted roaming are designed to influence the AP that a client associates with, it is not possible to enable both the options at the same time on a WLAN.

## Restrictions for Assisted Roaming

- The assisted roaming feature is supported across multiple devices.
- This feature is supported only on 802.11n capable indoor access points. For a single band configuration, a maximum of 6 neighbors are visible in a neighbor list. For dual band configuration, a maximum of 12 neighbors are visible.
- You can configure assisted roaming only using the device CLI.

# How to Configure Assisted Roaming

## Configuring Assisted Roaming (CLI)

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 2</b>	<b>wireless assisted-roaming floor-bias dBm</b> <b>Example:</b> Device(config)# <code>wireless assisted-roaming floor-bias 20</code>	Configures neighbor floor label bias. The valid range is from 5 to 25 dBm, and the default value is 15 dBm.
<b>Step 3</b>	<b>wlan wlan-id</b> <b>Example:</b> Device(config)# <code>wlan wlan1</code>	Enters the WLAN configuration submode. The <i>wlan-name</i> is the profile name of the configured WLAN.
<b>Step 4</b>	<b>assisted-roaming neighbor-list</b> <b>Example:</b> Device(wlan)# <code>assisted-roaming neighbor-list</code>	Configures an 802.11k neighbor list for a WLAN. By default, assisted roaming is enabled on the neighbor list when you create a WLAN. The <b>no</b> form of the command disables assisted roaming neighbor list.
<b>Step 5</b>	<b>assisted-roaming dual-list</b> <b>Example:</b> Device(wlan)# <code>assisted-roaming dual-list</code>	Configures a dual-band 802.11k dual list for a WLAN. By default, assisted roaming is enabled on the dual list when you create a WLAN. The <b>no</b> form of the command disables assisted roaming dual list.
<b>Step 6</b>	<b>assisted-roaming prediction</b> <b>Example:</b> Device(wlan)# <code>assisted-roaming prediction</code>	Configures assisted roaming prediction list feature for a WLAN. By default, the assisted roaming prediction list is disabled. <b>Note</b> A warning message is displayed and load balancing is disabled for the WLAN if load balancing is already enabled for the WLAN.

	Command or Action	Purpose
<b>Step 7</b>	<b>wireless assisted-roaming prediction-minimum</b> <i>count</i>  <b>Example:</b> Device# <b>wireless assisted-roaming prediction-minimum</b>	Configures the minimum number of predicted APs required for the prediction list feature to be activated. The default value is 3.  <b>Note</b> If the number of the AP in the prediction assigned to the client is less than the number that you specify, the assisted roaming feature will not apply on this roam.
<b>Step 8</b>	<b>wireless assisted-roaming denial-maximum</b> <i>count</i>  <b>Example:</b> Device# <b>wireless assisted-roaming denial-maximum 8</b>	Configures the maximum number of times a client can be denied association if the association request is sent to an AP does not match any AP on the prediction. The valid range is from 1 to 10, and the default value is 5.
<b>Step 9</b>	<b>end</b>  <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

## Verifying Assisted Roaming

The following command can be used to verify assisted roaming configured on a WLAN:

Command	Description
<b>show wlan id</b> <i>wlan-id</i>	Displays the WLAN parameters on the WLAN.

## Configuration Examples for Assisted Roaming

This example shows how to configure the neighbor floor label bias:

```
Device# configure terminal
Device(config)# wireless assisted-roaming floor-bias 10
Device(config)# end
Device# show wlan id 23
```

This example shows how to disable neighbor list on a specific WLAN:

```
Device# configure terminal
Device(config)# wlan test1
Device(config) (wlan)# no assisted-roaming neighbor-list
Device(config) (wlan)# end
Device# show wlan id 23
```

This example shows how to configure the prediction list on a specific WLAN:

```
Device# configure terminal
Device(config)# wlan test1
Device(config) (wlan) # assisted-roaming prediction
Device(config) (wlan) # end
Device# show wlan id 23
```

This example shows how to configure the prediction list based on assisted roaming prediction threshold and maximum denial count on a specific WLAN:

```
Device# configure terminal
Device(config)# wireless assisted-roaming prediction-minimum 4
Device(config)# wireless assisted-roaming denial-maximum 4
Device(config) (wlan) # end
Device# show wlan id 23
```

## Additional References for Assisted Roaming

### Related Documents

Related Topic	Document Title
System management commands	<i>System Management Command Reference (Catalyst 3850 Switches)</i>

### Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

### Standards and RFCs

Standard/RFC	Title
802.11k	—

### MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information For Performing Assisted Roaming Configuration

Feature Name	Release	Feature Information
Assisted Roaming	Cisco IOS XE 3.2SE	This feature was introduced.



## CHAPTER 169

# Configuring Access Point Groups

- [Finding Feature Information, on page 2953](#)
- [Prerequisites for Configuring AP Groups, on page 2953](#)
- [Restrictions on Configuring Access Point Groups, on page 2954](#)
- [Information About Access Point Groups, on page 2954](#)
- [How to Configure Access Point Groups, on page 2955](#)
- [Additional References, on page 2957](#)
- [Feature History and Information for Access Point Groups, on page 2958](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Prerequisites for Configuring AP Groups

The following are the prerequisites for creating access point groups on a device:

- The required access control list (ACL) must be defined on the router that serves the VLAN or subnet.
- Multicast traffic is supported with access point group VLANs. However, if the client roams from one access point to another, the client might stop receiving multicast traffic, unless IGMP snooping is enabled.

### Related Topics

[Information About Access Point Groups, on page 2954](#)

[Restrictions on Configuring Access Point Groups, on page 2954](#)

## Restrictions on Configuring Access Point Groups

- Suppose that the interface mapping for a WLAN in the AP group table is the same as the WLAN interface. If the WLAN interface is changed, the interface mapping for the WLAN in the AP group table also changes to the new WLAN interface.

Suppose that the interface mapping for a WLAN in the AP group table is different from the one defined for the WLAN. If the WLAN interface is changed, then the interface mapping for the WLAN in the AP group table does not change to the new WLAN interface.

- If you clear the configuration on the device, all of the access point groups disappear except for the default access point group “default-group,” which is created automatically.
- The default access point group can have up to 16 WLANs associated with it. The WLAN IDs for the default access point group must be less than or equal to 16. If a WLAN with an ID greater than 16 is created in the default access point group, the WLAN SSID will not be broadcasted. All WLAN IDs in the default access point group must have an ID that is less than or equal to 16. WLANs with IDs greater than 16 can be assigned to custom access point groups.
- We recommend that you configure all Flex+Bridge APs in a mesh tree (in the same sector) in the same AP group and the same FlexConnect group, to inherit the WLAN-VLAN mappings properly.
- Whenever you add a new WLAN to an AP group, radio reset occurs and if any client is in connected state, the client is deauthenticated and is required to reconnect. We recommend that you add or modify the WLAN configuration of an AP group only during maintenance windows to avoid outages.
- The number of AP groups that you can configure cannot be more than the number of ap-count licenses on Cisco WLC. For example, if your Cisco WLC has 5 ap-count licenses, the maximum number of AP groups that you can configure is 5, including the default AP group.

### Related Topics

[Information About Access Point Groups](#), on page 2954

[Prerequisites for Configuring AP Groups](#), on page 2953

## Information About Access Point Groups

After you create up to 512 WLANs on the device, you can selectively publish them (using access point groups) to different access points to better manage your wireless network. In a typical deployment, all users on a WLAN are mapped to a single interface on the device. Therefore, all users that are associated with that WLAN are on the same subnet or VLAN. However, you can choose to distribute the load among several interfaces or to a group of users based on specific criteria such as individual departments (such as Marketing) by creating access point groups. Additionally, these access point groups can be configured in separate VLANs to simplify network administration.

### Related Topics

[Creating Access Point Groups](#), on page 2955

[Viewing Access Point Group](#), on page 2956

[Assigning an Access Point to an AP Group](#), on page 2956

[Prerequisites for Configuring AP Groups](#), on page 2953

[Restrictions on Configuring Access Point Groups](#), on page 2954



# How to Configure Access Point Groups

## Creating Access Point Groups

### Before you begin

You must have administrator privileges to perform this operation.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 2</b>	<b>ap group ap-group-name</b> <b>Example:</b> Device(config)# <b>ap group my-ap-group</b>	Creates an access point group.
<b>Step 3</b>	<b>wlan wlan-name</b> <b>Example:</b> Device(config-apgroup)# <b>wlan wlan-name</b>	Associates the AP group to a WLAN.
<b>Step 4</b>	(Optional) <b>vlan vlan-name</b> <b>Example:</b> Device(config-apgroup)# <b>vlan test-vlan</b>	Assigns the access point group to a VLAN.
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# <b>end</b>	Returns to privileged EXEC mode. Alternatively, you can also press <b>Ctrl-Z</b> to exit global configuration mode.

### Example

This example shows how to create an AP group:

```
Device# configure terminal
Device(config-apgroup)# ap group test-ap-group-16
Device(config-wlan-apgroup)# wlan test-ap-group-16
Device(config-wlan-apgroup)# vlan VLAN1300
```

### Related Topics

[Information About Access Point Groups](#), on page 2954

## Assigning an Access Point to an AP Group

### Before you begin

You must have administrator privileges to perform this operation.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>ap name</b> <i>ap-name</i> <b>ap-group-name</b> <i>ap-group</i></p> <p><b>Example:</b></p> <pre>Device# ap name 1240-101 ap-groupname apgroup_16</pre>	<p>Assigns the access point to the access point group. The keywords and arguments are as follows:</p> <ul style="list-style-type: none"> <li>• <b>name</b>—Specifies that the argument following this keyword is the name of an AP that is associated to the device.</li> <li>• <i>ap-name</i>—AP that you want to associate to the AP group.</li> <li>• <b>ap-group-name</b>—Specifies that the argument following this keyword is the name of the AP group that is configured on the device.</li> <li>• <i>ap-group</i>—Name of the access point group that is configured on the device.</li> </ul>

### Related Topics

[Information About Access Point Groups](#), on page 2954

## Viewing Access Point Group

### Before you begin

You must have administrator privileges to perform this operation.

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<p><b>show ap groups</b> [<b>extended</b> ]</p> <p><b>Example:</b></p> <pre>Device# show ap groups</pre>	<p>Displays the AP groups configured on the device. The <b>extended</b> keyword displays all AP Groups information defined in the system in detail.</p>

### Related Topics

[Information About Access Point Groups](#), on page 2954

# Additional References

## Related Documents

Related Topic	Document Title
WLAN commands	<i>WLAN Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>
Lightweight Access Point configuration	<i>Lightweight Access Point Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>
Lightweight Access Point commands	<i>Lightweight Access Point Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)</i>

## Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	<a href="https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi">https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi</a>

## MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

## Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature History and Information for Access Point Groups

This table lists the features in this modules and provides links to specific configuration information.

Feature Name	Release	Feature Information
AP Groups	Cisco IOS XE 3.2SE	This feature was introduced.



## PART **XXIII**

### **Data Models**

- [Configuring YANG Datamodel, on page 2961](#)
- [Finding Feature Information, on page 2967](#)





## CHAPTER 170

# Configuring YANG Datamodel

- [Finding Feature Information](#), on page 2961
- [Restrictions for Data Models](#), on page 2961
- [Introduction to Data Models - Programmatic and Standards-Based Configuration](#), on page 2961
- [How to Configure Data Models](#), on page 2962
- [Additional References for Data Models](#), on page 2965
- [Feature Information for Data Models](#), on page 2965

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

## Restrictions for Data Models

The NETCONF feature is not supported on a device running dual IOSd configuration or software redundancy.

## Introduction to Data Models - Programmatic and Standards-Based Configuration

The traditional way of managing network devices is by using Command Line Interfaces (CLIs) for configurational (configuration commands) and operational data (show commands). For network management, Simple Network Management Protocol (SNMP) is widely used, especially for exchanging management information between various network devices. Although CLIs and SNMP are heavily used, they have several restrictions. CLIs are highly proprietary, and human intervention is required to understand and interpret their text-based specification. SNMP does not distinguish between configurational and operational data.

The solution lies in adopting a programmatic and standards-based way of writing configurations to any network device, replacing the process of manual configuration. Network devices running on Cisco IOS XE support the automation of configuration for multiple devices across the network using data models. Data models are developed in a standard, industry-defined language, that can define configuration and state information of a network.

Cisco IOS XE supports the Yet Another Next Generation (YANG) data modeling language. YANG can be used with the Network Configuration Protocol (NETCONF) to provide the desired solution of automated and programmable network operations. NETCONF (RFC 6241) is an XML-based protocol that client applications use to request information from and make configuration changes to the device. YANG is primarily used to model the configuration and state data used by NETCONF operations.

In Cisco IOS XE, model-based interfaces interoperate with existing device CLI, Syslog, and SNMP interfaces. These interfaces are optionally exposed northbound from network devices. YANG is used to model each protocol based on RFC 6020.



---

**Note** To access Cisco YANG models in a developer-friendly way, please clone the [GitHub repository](#), and navigate to the [vendor/cisco](#) subdirectory. Models for various releases of IOS-XE, IOS-XR, and NX-OS platforms are available here.

---

## NETCONF

NETCONF provides a simpler mechanism to install, manipulate, and delete the configuration of network devices.

It uses an Extensible Markup Language (XML)-based data encoding for the configuration data as well as the protocol messages.

NETCONF uses a simple RPC-based (Remote Procedure Call) mechanism to facilitate communication between a client and a server. The client can be a script or application typically running as part of a network manager. The server is typically a network device (switch or router). It uses Secure Shell (SSH) as the transport layer across network devices.

NETCONF also supports capability discovery and model downloads. Supported models are discovered using the *ietf-netconf-monitoring* model. Revision dates for each model are shown in the capabilities response. Data models are available for optional download from a device using the *get-schema* rpc. You can use these YANG models to understand or export the data model.

For more details, refer RFC 6241.

# How to Configure Data Models

## Configuring NETCONF

### Before you begin

You must configure NETCONF-YANG as follows.



**Procedure**

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> <b>enable</b>	Enables privileged EXEC mode. <ul style="list-style-type: none"><li>• Enter your password if prompted.</li></ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# <b>configure terminal</b>	Enters global configuration mode.
<b>Step 3</b>	<b>netconf-yang</b> <b>Example:</b> Device (config)# <b>netconf-yang</b>	Enables the NETCONF interface on your network device. <b>Note</b> After the initial enablement through the CLI, network devices can be managed subsequently through a model based interface. The complete activation of model-based interface processes may require up to 90 seconds.
<b>Step 4</b>	<b>exit</b> <b>Example:</b> Device (config)# <b>exit</b>	Exits global configuration mode.

## Configuring NETCONF Options

### Configuring SNMP

Enable the SNMP Server in IOS to enable NETCONF to access SNMP MIB data using YANG models generated from supported MIBs, and to enable supported SNMP traps in IOS to receive NETCONF notifications from the supported traps.

Perform the following steps:

**Procedure**

**Step 1** Enable SNMP features in IOS.

**Example:**

```
configure terminal
logging history debugging
logging snmp-trap emergencies
logging snmp-trap alerts
logging snmp-trap critical
logging snmp-trap errors
logging snmp-trap warnings
logging snmp-trap notifications
```

```

logging snmp-trap informational
logging snmp-trap debugging
!
snmp-server community public RW
snmp-server trap link ietf
snmp-server enable traps snmp authentication linkdown linkup snmp-server enable traps syslog
snmp-server manager
exit

```

**Step 2** After NETCONF-YANG starts, enable SNMP Trap support by sending the following RPC <edit-config> message to the NETCONF-YANG port.

**Example:**

```

<?xml version="1.0" encoding="utf-8"?>
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="">
  <edit-config>
    <target>
      <running/>
    </target>
    <config>
      <netconf-yang xmlns="http://cisco.com/yang/cisco-self-mgmt">
        <cisco-ia xmlns="http://cisco.com/yang/cisco-ia">
          <snmp-trap-control>
            <trap-list>
              <trap-oid>1.3.6.1.4.1.9.9.41.2.0.1</trap-oid>
            </trap-list>
            <trap-list>
              <trap-oid>1.3.6.1.6.3.1.1.5.3</trap-oid>
            </trap-list>
            <trap-list>
              <trap-oid>1.3.6.1.6.3.1.1.5.4</trap-oid>
            </trap-list>
          </snmp-trap-control>
        </cisco-ia>
      </netconf-yang>
    </config>
  </edit-config>
</rpc>

```

**Step 3** Send the following RPC message to the NETCONF-YANG port to save the running configuration to the startup configuration.

**Example:**

```

<?xml version="1.0" encoding="utf-8"?>
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="">
  <cisco-ia:save-config xmlns:cisco-ia="http://cisco.com/yang/cisco-ia"/>
</rpc>

```

---

## Additional References for Data Models

### Related Documents

Related Topic	Document Title
YANG data models for various release of IOS-XE, IOS-XR, and NX-OS platforms	To access Cisco YANG models in a developer-friendly way, please clone the <a href="#">GitHub repository</a> , and navigate to the <a href="#">vendor/cisco</a> subdirectory. Models for various releases of IOS-XE, IOS-XR, and NX-OS platforms are available here.

### Standards and RFCs

Standard/RFC	Title
RFC 6020	<i>YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)</i>
RFC 6241	<i>Network Configuration Protocol (NETCONF)</i>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for Data Models

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

*Table 230: Feature Information for Programmability: Data Models*

Feature Name	Release	Feature Information
Data Models	Cisco IOS XE Denali 16.3.1	<p>The Data Models feature facilitates a programmatic and standards-based way of writing configurations and reading operational data from network devices.</p> <p>The following command was introduced: <b>netconf-yang.</b></p>



## CHAPTER 171

# Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.

- [Information About Programmability, on page 2967](#)
- [How to Configure Programmability: Network Bootloader, on page 2970](#)
- [Configuration Examples for Programmability: Network Bootloader, on page 2971](#)
- [Additional References for iPXE, on page 2972](#)
- [Feature Information for iPXE, on page 2972](#)

## Information About Programmability

### iPXE Overview

Network bootloaders support booting from a network-based source. The bootloaders boot an image located on an HTTP, FTP, or TFTP server. A network boot source is detected automatically by using an iPXE-like solution.

iPXE enables network boot for a device that is offline. The following are the three types of iPXE boot modes:

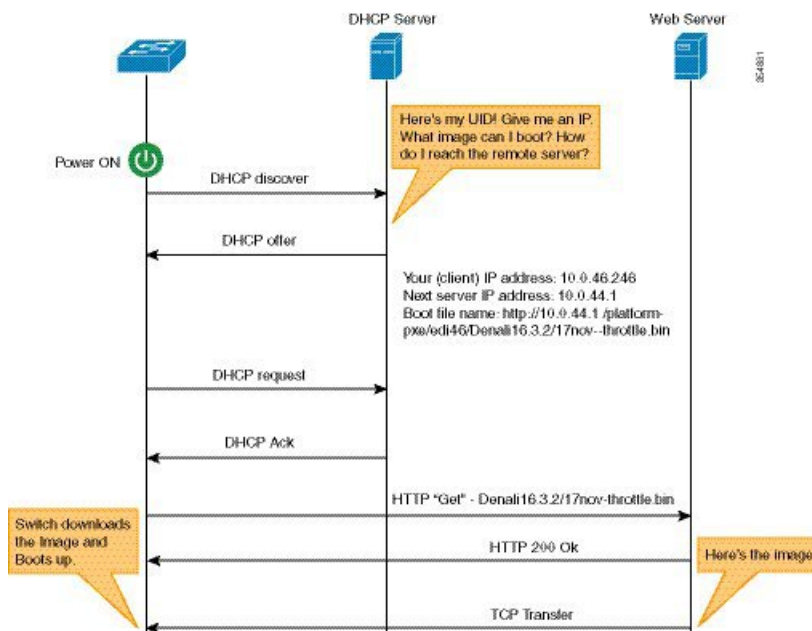
- **iPXE Timeout**—Configures a timeout in seconds for iPXE network boot by using the `IPXE_TIMEOUT` rommon variable. When the timeout expires, device boot is activated.
- **iPXE Forever**—Boots through iPXE network boot. The device sends DHCP requests forever, when the **boot ipxe forever** command is configured. This is an iPXE-only boot (which means that the bootloader will not fall back to a device boot or a command prompt, because it will send DHCP requests forever until it receives a valid DHCP response.)
- **Device**—Boots using the local device BOOT line configured on it. When device boot is configured, the configured `IPXE_TIMEOUT` rommon variable is ignored. Device boot is the default boot mode.



**Note** Manual boot is another term used in this document. Manual boot is a flag that determines whether to do a rommon reload or not. When the device is in rommon mode, you have to manually issue the **boot** command. If manual boot is set to 1, the rommon or device prompt is activated. If manual boot is set to 0, the device is reloaded; but rommon mode is not activated.

The following section describes how an iPXE bootloader works:

**Figure 155: iPXE Bootloader Workflow**



1. Bootloader sends a DHCP request.
2. The DHCP response includes the IP address and boot file name. The boot file name indicates that the boot image is to be retrieved from a TFTP server (tftp://server/filename), FTP server (ftp://userid:password@server/filename), or an HTTP server (http://server/filename). Because the current iPXE implementation works only via the management port (GigabitEthernet0/0), DHCP requests sent through the front panel ports are not supported.
3. Bootloader downloads and boots the image from the network source.
4. If no DHCP response is received, the bootloader keeps sending DHCP requests forever or for a specified period of time, based on the boot mode configured. When a timeout occurs, the bootloader reverts to a device-based boot. The device sends DHCP requests forever only if the configured boot mode is **ipxe-forever**. If the **ipxe-timeout** boot mode command is configured, DHCP requests are sent for the specified amount of time, and when the timeout expires, device boot mode is activated.

When manual boot is disabled, the bootloader determines whether to execute a device boot or a network boot based on the configured value of the iPXE ROMMON variable. Irrespective of whether manual boot is enabled or disabled, the bootloader uses the BOOTMODE variable to determine whether to do a device boot or a network boot. Manual boot means that the user has to manually type the **boot manual switch** command to

start the boot process. When manual boot is disabled, and when the device reloads, the boot process starts automatically.

When iPXE is disabled, the contents of the existing BOOT variable are used to determine how to boot the device. The BOOT variable may contain a network-based uniform resource identifier (URI) (for example, http://, ftp://, tftp://), and a network boot is initiated; however DHCP is not used to get the network image path. The device IP address is taken from the IP\_ADDR variable. The BOOT variable may also contain a device-based path, in which case, a device-based boot is initiated.

To identify the device on a remote DHCP server for booting purposes, use the chassis serial number (available in DHCP option 61), the Product ID (PID) (available in DHCP Option 60), or the device MAC Address. The **show inventory** and **show switch** commands also display these values on the device.

The following is sample output from the show inventory command:

```
Device# show inventory

NAME:"c38xx Stack", DESCR:"c38xx Stack"
PID:WS-3850-12X-48U-L, VID:V01 , SN: F0C1911V01A

NAME:"Switch 1", DESCR:"WS-C3850-12X48U-L"
PID:WS-C3850-12X48U-L, VID:V01 , SN:F0C1911V01A

NAME:"Switch1 -Power Supply B", DESCR:"Switch1 -Power Supply B"
PID:PWR-C1-1100WAC, VID:V01, SN:LIT1847146Q
```

The following common variables should be configured for iPXE:

- BOOTMODE = ipxe-forever | ipxe-timeout | device
- IPXE\_TIMEOUT = seconds

## Plug-N-Play Agent Overview

The Cisco Plug-N-Play (PnP) Agent works as a platform bootstrap agent. The device-based bootstrap agent interoperates with the identified bootstrap servers.

A platform bootstrap agent/PnP agent supports the following common requirements:

- On-Premises, Out-of-Band Bootstrap—Uses DHCP over management port.
- Off-Premises, Out-of-Band Bootstrap—Uses cloud-based connect over management port, for example, using DNS and Cisco PnP protocol.
- Off-Premises, In-Band Bootstrap—Uses cloud-based connect over data ports, for example using DNS and Cisco PnP protocol

# How to Configure Programmability: Network Bootloader

## Configuring iPXE

### Procedure

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<ul style="list-style-type: none"> <li>• <b>boot ipxe forever</b> <i>switch number</i></li> <li>• <b>boot ipxe timeout</b> <i>seconds switch number</i></li> </ul> <b>Example:</b> Device(config)# boot ipxe forever switch 2 <b>Example:</b> Device(config)# boot ipxe timeout 30 switch 2	Configures the BOOTMODE rommon variable. <ul style="list-style-type: none"> <li>• The <b>forever</b> keyword configures the BOOTMODE rommon variable as IPXE-FOREVER.</li> <li>• The <b>timeout</b> keyword configures the BOOTMODE rommon variable as IPXE-TIMEOUT.</li> </ul>
<b>Step 4</b>	<b>boot system</b> { <b>switch</b> <i>switch-number</i>   <b>all</b> } { <b>flash:</b>   <b>ftp:</b>   <b>http:</b>   <b>tftp:</b> } <b>Example:</b> Device(config)# boot system switch 1 http://192.0.2.42/image-filename or Device(config)# boot system switch 1 http://[2001:db8::1]/image-filename	Boots an image from the specified location. <ul style="list-style-type: none"> <li>• You can either use an IPv4 or an IPv6 address for the remote FTP/HTTP/TFTP servers.</li> <li>• You must enter the IPv6 address inside the square brackets (as per RFC 2732); if not the device will not boot.</li> </ul>
<b>Step 5</b>	<b>end</b> <b>Example:</b> Device(config)# end	Exits global configuration mode and returns to privileged EXEC mode.

## Configuring Device Boot

You can either use the **no boot ipxe** or the **default boot ipxe** command to configure device boot.



**Procedure**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b> <b>Example:</b> Device> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b> <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<ul style="list-style-type: none"> <li>• no boot ipxe</li> <li>• default boot ipxe</li> </ul> <b>Example:</b> Device(config)# no boot ipxe <b>Example:</b> Device(config)# default boot ipxe	Configures device boot. The default boot mode is device boot.  Enables default configuration on the device.
<b>Step 4</b>	<b>end</b> <b>Example:</b> Device(config)# end	Exits global configuration mode and returns to privileged EXEC mode.

# Configuration Examples for Programmability: Network Bootloader

## Example: iPXE Configuration

The following example shows that iPXE is configured to send DHCP requests forever until the device boots with an image:

```
Device# configure terminal
Device(config)# boot ipxe forever switch 2
Device(config)# end
```

The following example shows how to configure the boot mode to ipxe-timeout. The configured timeout is 200 seconds. If an iPXE boot failure occurs after the configured timeout expires, the configured device boot is activated. In this example, the configured device boot is `http://[2001:db8::1]/image-filename`.

```
Device# configure terminal
Device(config)# boot ipxe timeout 200 switch 2
Device(config)# boot system http://[2001:db8::1]/image-filename
Device(config)# end
```

## Additional References for iPXE

### Related Documents

Related Topic	Document Title
Programmability commands	<a href="#">Command Reference, (Catalyst 3850 Switches)</a>

### Standards and RFCs

Standard/RFC	Title
RFC 3315	<i>Dynamic Host Configuration Protocol for IPv6 (DHCPv6)</i>
RFC 3986	<i>Uniform Resource Identifier (URI): Generic Syntax</i>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/support">http://www.cisco.com/support</a>

## Feature Information for iPXE

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

*Table 231: Feature Information for iPXE*

<b>Feature Name</b>	<b>Release</b>	<b>Feature Information</b>
iPXE	Cisco IOS XE Denali 16.5.1a	Network Bootloaders support booting from a device-based or network-based source. A network boot source must be detected automatically by using an iPXE-like solution.

