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# Connected Utilities Virtual RTU Implementation Guide

This implementation guide includes the following major sections:

Introduction, page 1	Introduction to the Virtual RTU application and SCADA protocol matrix supported by Virtual RTU.
System Use Cases, page 4	Description of the Secondary Substation Monitoring, Distribution Automation, and Protocol translation use cases.
System Overview and Components, page 9	Overview of system topology and description of the hardware and software components used in the Virtual RTU system.
Lifecycle Management Implementation, page 11	Implementation details of the Lifecycle Management with reference to Virtual RTU and the Cisco IR 8x9 Integrated Services Router.
SCADA Protocol Translation Use Case using Virtual RTU, page 30	Implementation details of Virtual RTU protocol translation use cases.
Limitations, page 83	Description of Virtual RTU system limitations.
References, page 83	List of references that are relevant to Virtual RTU.
Glossary, page 84	Acronyms and initialisms used in this document.

## Introduction

This chapter includes the following topics

- Overview, page 1
- Audience and Scope, page 2
- Implementation Workflow, page 3

## Overview

This document captures implementation details of the Virtual Remote Terminal Unit (Virtual RTU) application on the Cisco IR8x9 Integrated Services Router and Cisco IR1101 Integrated Services Router Rugged, which can be deployed as a secondary substation or as a distribution automation gateway. The Virtual RTU application's lifecycle is managed using the Cisco Internet of Things (IoT) Field Network Director (FND). Eximprod, which provides our Supervisory Control and Data Acquisition (SCADA), is a Cisco Solution partner. The ES200 is Eximprod's Virtual RTU application. When we use Virtual RTU terminology in this document, we are referring to the only software we have validated—the ES200.

Use cases that have been addressed in this guide are SCADA visibility and monitoring of secondary substation intelligent end devices (IEDs), SCADA protocol translations, and life cycle management of Virtual RTU. Later, this document will be expanded to include distribution automation use cases such as Fault Location Identification and Service Restoration (FLISR) and Volt/VAR. Finally, this information will be integrated into the Secondary Substation CVD planned efforts that are under the umbrella of the Cisco Field Area Network (FAN) Solution.

#### Introduction

Protocol translation supported matrix support by Virtual RTU is shown in Table 1.

Communication Protocol	Туре	Communication Mode Serial RS232/RS485	Communication Mode Ethernet TCP/IP
Modbus	Master/Client Slave/Server	Yes No	Yes Yes
DNP3	Master/Client Slave/Server	Yes	Yes
IEC 608750-5-104	Master/Client Slave/Server	NA NA	Yes
IEC 61850 MMS	Client	NA	Yes

### Table 1 Virtual RTU SCADA Protocol Translation Communication Mode Matrix

Virtual RTU ES200 will work as the Modbus/DNP3/IEC 61850-MMS master to Southbound SCADA clients in the secondary substation (or distribution feeder controller) and, in turn, can act as the Modbus/DNP3 Slave/T104 to Northbound Distribution System Operator (DSO) SCADA systems. Southbound of Virtual RTU can be Ethernet or RS232 and Northbound is Ethernet TCP/IP communication.

Southbound Protocol (Virtual RTU < > IED)	Northbound Protocol (Virtual RTU < > SCADA CC)	Virtual RTU support availability	Validated for this implementation guide
DNP3 - Serial	DNP3 - IP	Yes	Yes
DNP3 - IP	Modbus	Yes	Yes
DNP3 - IP	T104	Yes	Yes
IEC 61850 MMS	T104	Yes	Yes
IEC 61850 MMS	DNP3 - IP	Yes	Yes
Modbus	DNP3 - IP	Yes	No
Modbus	T104	Yes	No

#### Table 2 Virtual RTU SCADA Protocol Translation Support Matrix

For more details about Virtual RTU, please refer to the following:

- http://www.epg.ro/wp-content/uploads/2017/09/ES200-Datasheet-public.pdf
- https://en.wikipedia.org/wiki/Remote\_terminal\_unit

## Audience and Scope

The audience of this guide comprises, but is not limited to, system architects, network/compute/system engineers, field consultants, Cisco Advanced Services specialists, and customers.

This guide describes how to deploy edge compute applications. Readers should be familiar with networking protocols, Network Address Translation (NAT), and SCADA protocols, and have exposure to Edge computing and Field Area Network Solution Architecture.

Introduction

## Implementation Workflow

Figure 1 provides the high-level implementation flow for deploying Virtual RTU use cases.

### Figure 1 Virtual RTU Implementation Workflow



## System Use Cases

This chapter, which describes secondary substation monitoring, distribution automation, and SCADA Protocol translation use cases and how the use of Virtual RTU will benefit DSOs, includes the following major topics:

- Secondary Substation Monitoring, page 4
- Distribution (Feeder) Automation, page 5
- Virtual RTU and Protocol Translation, page 6

## Secondary Substation Monitoring

Secondary substations are used to step down the power voltage from medium (1kv - 40 kV) to low voltage (110/220 V). A secondary substation hosts a transformer and a number of devices called intelligent end devices (IEDs) such as circuit breakers, voltage sensors, reclosers, and surge protectors. IEDs are currently managed by a centralized application located at the DSO's Control Center called the SCADA. IEDs are connected to RTUs in the secondary substation. DSO SCADA software will be communicated to Remote RTUs to poll for the current register value associated with IEDs or to issue control command.

A secondary substation may also host a smart meter concentrator that collects data from the meters and performs local processing to report information back to the Control Center. Information and Communication Technology networks play a key role in connecting secondary substation RTUs to centralized SCADA systems.

#### Figure 2 Secondary Substation



In Figure 2, two different physical components are depicted: RTUs and the substation router. In the Virtual RTU use case, we are combining two different functionalities into one physical component: the Virtual RTU Eximprod ES200 application, which will be hosted on the Cisco IR809/IR1101 secondary substation router as an edge compute application container.

## Distribution (Feeder) Automation

Distribution Automation (DA) refers to the monitoring and control of devices located out on the feeders themselves such as line reclosers, load break switches, sectionalizers, capacitor banks, and line regulators.

Distribution Automation is the overlay network deployed in parallel to the Distribution Feeder to enable the two-way communication between controllers used in the Distribution Feeder and Intelligence Application that is residing in the Utility Control Center or Substation for improving grid reliability, availability, and control.

Figure 3 depicts a typical DA system.



#### Figure 3 Distribution Automation

Two important use cases for Distribution Automation are:

- FLISR
- DA Volt/VAR regulation

DA Volt/VAR Regulation and FLISR use cases will be deployed globally around the world. Cisco DA gateways such as Cisco IR807, IR807, and IR1101 will be deployed 1:1 with DA controllers, including the recloser controller and capacitor bank controllers.

## FLISR Use Case

Fault Location Isolation and Service Restoration (FLISR) is the process for dealing with fault conditions on the electrical grid. The following occurs as part of this process:

- 1. Detects (and locates) faults
- 2. Isolates the faults to the smallest segment of the grid possible
- 3. Restores as much service as possible while the fault is isolated

FLISR includes automatic sectionalizing and restoration and automatic circuit reconfiguration. These applications accomplish DA operations by coordinating operation of field devices, software, and dedicated communication networks to automatically determine the location of a fault, and then rapidly reconfigure the flow of electricity so that some or all of the customers can avoid experiencing outages.

Because FLISR operations rely on rerouting power, they typically require feeder configurations that contain multiple paths to single or multiple other substations. This creates redundancies in power supply for customers located downstream or upstream of a downed power line, fault, or other grid disturbance.

Benefits of FLISR include:

- Consumers experience minimal outage.
- Utilities improve their System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI) numbers and avoid financial penalties that could be levied by the regulator.

## Volt/VAR Use Case

This use case address automating dynamic and efficient delivery of power. Utilities look at achieving large savings by enhancing the efficiency of their power distribution infrastructure; in other words, improving the effectiveness of the flow of electricity. In order to evaluate the process, it is important to review the differences between what is called *real power* and *reactive power*.

Real power is what we use to run all lights, devices, and production lines. It is the power that does the work. Reactive power does not contribute anything to doing work, but it does cause conductors to heat up and takes up a certain amount of space in the wires. The more reactive power flowing on a line, the less room exists for real power and the less efficient is the distribution system.

Today, in order to eliminate or at least minimize reactive power flows, utilities have deployed on their local distribution systems devices such as capacitor banks or special transformers that are typically located at substations or on a feeder. These devices work to keep reactive power flows down, making the full capacity of the conductor available for the real power. This process is known as Volt/VAR regulation or control.

- VAR Compensation-Improves efficiency of energy supply by ensuring voltage and current are in phase when supplied to the customer.
- Conservation Voltage Regulation-During peak load, ensures the minimum required voltage level is supplied to the customer.

Most existing deployments have a centralized approach of controlling DA controllers from the DSO Control Center using SCADA applications. Utilities are moving towards distributed control approach where decisions can be made more quickly at the distribution feeder level by running customer business logic at the DA Gateway level. Cisco IR809 plays a perfect role for these deployment scenarios since we can host Virtual RTU software that allows utilities to implement customer business logic according to their requirements and needs.

## Virtual RTU and Protocol Translation

## Virtual RTU

Eximprod ES200 over the Cisco IR8x9 and IR1101 series, as shown in Figure 4, is a fourth-generation (Internet of Things or IoT) SCADA RTU gateway for control, measurement, and supervision in power distribution systems. ES200 is designed to efficiently operate secondary distribution substations, feeders, and electrical substations using modern and secure communication and automation standards.

Virtual RTU can integrate existing multi-vendor equipment and runs SCADA software without dedicated hardware. Since it is software based, RTU time to deploy and add new features can be done more quickly than with legacy hardware RTU. Security features and customer business logic can be implemented based on customer requirements.



## SCADA Protocol Translation

SCADA protocol translations are needed when DSO is running different (or advance) SCADA protocols as compared to field devices in secondary substation IEDs or distribution feeder controllers. Another scenario for protocol translations is when the last mile (such as between DA gateway and field devices) is connected via a legacy RS232 connection, but the DSO connections are migrated to Ethernet TCP/IP.

Figure 5 depicts a SCADA protocol translation scenario where the DSO SCADA uses the Modbus TCP Protocol, but sensors and actuators in the secondary substation are using Distributed Network Protocol 3 (DNP3).



Figure 5 SCADA Protocol Translation using Virtual RTU

The SCADA protocol translation matrix supported by Virtual RTU is explained in Introduction, page 1. The various SCADA protocol translation implementations are explained in SCADA Protocol Translation Use Case using Virtual RTU, page 30.

Note: The protocol translations are not related to the implementation of Cisco IOS.

## IEC 61850 SCADA Protocol Translation

This translation from IEC 61850 MMS to T104 or DNP3 and *vice versa* is achieved by using Virtual RTU running on the edge gateway.





- 1. The Control Relay Output Blocks (CROB) Control command on the DNP3 Binary Output register is initiated from the SCADA Control Center to the ES200 application
- 2. The ES200 application translates the DNP3 Binary Output point to the IEC 61850 Binary point and forwards it to the IED Oper.OperVal register where actual control is required.
- 3. The Oper.OperVal updates the status to the Pos.Oper.ctVal register.

#### System Overview and Components

- 4. IEC 61850 then updates the ES200 IEC 61850 client about this updated value. The ES200 internally translates the Analog Input to the DNP3 Double Input point.
- 5. The unsolicited reporting feature of DNP3 would immediately report the updated value to the SCADA Control Center.

## System Overview and Components

The solution is comprised of the Utilities Distributed System Operator Control Center block (the green cloud in the solution topology in Figure 7), the Wide Area Network (WAN) block, and the Secondary Substation block.

The Cisco IoT FND and SCADA software are installed on the DSO. The Cisco ASR 1000 series router is acting as the Headend Router (HER/Control Center router), which terminates the encrypted tunnels from different secondary substation routers. Encrypted tunnels carry SCADA traffic. HER decrypts and routes SCADA traffic to DSO SCADA systems. The Cisco IoT FND is used for lifecycle management of the Virtual RTU application. For more information about Cisco ASR 1000, please refer to Cisco ASR 1000 Series Aggregation Services Routers at the following URL:

https://www.cisco.com/c/en/us/products/routers/asr-1000-series-aggregation-services-routers/index.html

Backhaul to the DSO Control Center can be Ethernet or cellular. Backhaul can be fully secured through Cisco's VPN technologies such as Cisco Dynamic Multipoint Virtual Private Network (DMVPN) and Cisco FlexVPN.



#### Figure 7 Virtual RTU Solution Topology

In the topology in Figure 7, the Virtual RTU ES200 software is installed on the Cisco IR809, which is acting as a secondary substation router. Sensors and actuators are simulated using a PC running the Triangle MicroWorks (TMW) Protocol Test Harness application and Distributed Test Manager (DTM). A PC running TMW is connected to the Cisco IR809/IR1101 using Ethernet and serial (RS232) interfaces. This guide will be later enhanced to include Distribution Automation use

### System Overview and Components

cases. Table 3 lists the hardware and software combination used in solution validation.

Device	Software version
Cisco IR809	Refer to the following URL:
	https://software.cisco.com/download/home/286287094/type/280805680/ release/15.8.3M2a
Cisco IR1101	Refer to the following URL:
	https://software.cisco.com/download/home/286319772/type/282046477/ release/Gibraltar-16.12.1
Cisco Fog Director	1.8.1 was the latest available version during validation.
	1.9.0 is the latest available version in CCO, released during the documentation phase.
Eximprod ES200	Docker container
	PaaS application
	ir1101_es200_3.8.tar
	es200_ir809_3.8.tar
Distributed Test Manager (DSO Center SCADA and IED simulators)	1.4.0.4
Protocol Test Harness (Southbound IED simulator)	3.17.3.0

### Table 3 Hardware and Software Matrix

**Note:** Contact Eximprod's team at https://www.epg.ro/en/contact/, to download Eximprod's Virtual RTU software and to generated to license for Eximprod's license for edge devices.

## Lifecycle Management Implementation

This chapter includes the following major topics:

- Cisco IR809 Prerequisites, page 11
- Cisco IR1101 Prerequisites, page 14
- Cisco Fog Director, page 17
- ES200 Lifecycle Management, page 26

## Cisco IR809 Prerequisites

## Image and Upgrade Details

**Note:** Cisco IR809 should be running with a minimum 15.6 version to support the Docker container application. For details, please refer to the release notes at the following URL:

https://www.cisco.com/c/en/us/td/docs/routers/access/800/829/15-6-3M2-Release-Notes.html

It is recommended to install the latest image version from the https://software.cisco.com/download/home website.

- 1. Download and copy the Cisco IR809 bundle image to the Cisco IR809 flash drive.
- 2. Stop guest OS:

guest-os 1 stop

3. Upgrade guest OS using the following command. After upgrading, restart the router.

bundle install flash:<bundle\_image\_name>

4. Verify the upgrade using the following command:

```
DEM01-89-250#show platform guest-os

Guest OS status:

Installation: Cisco-GOS,version-1.3.2.3

State: RUNNING

DEM01-89-250#show iox host list

Host Name IPV4 Address IPV6 Address IOX Client

Version

DEM01-89-250-GOS-1 192.168.1.250 fe80::1ff:fe90:8b05 0.4
```

#### 5. Make sure you have the correct licenses:

License UDI:

Device# PID SN \*1 IR809G-LTE-GA-K9 JMX1941X00B Suite License Information for Module:'ir800'

Suite	Suite Currer	nt Typ	)e 	Suite Next reboot	:
Technology F	ackage License Informa	ation for Modu	ıle:'ir800'		
Technology	Technology-package Current	Туре	Technolog Next rebo	ry-package oot	
ipbase security data	ipbasek9 securityk9 datak9	Permanent Permanent Permanent	ipbasek9 securityk datak9	:9	

6. WAN interface configuration for Northbound communication towards DSO Control Center:

```
interface GigabitEthernet0
description to WAN Backhaul
ip address 10.10.70.89 255.255.255.0
ip nat outside
ip virtual-reassembly in
duplex auto
speed auto
```

**Note:** If Cellular is used as an underlay WAN interface, ignore the GigabitEthernet interface configuration and configure the Cellular interface. For details on the Cellular configuration, refer to the *Distribution Automation – Secondary Substation (Design Guide)* at the following URL:

 https://www.cisco.com/c/en/us/td/docs/solutions/Verticals/Distributed-Automation/Secondary-Substation/DG/ DA-SS-DG.html

#### 7. Internal interface to IOx:

```
interface GigabitEthernet2
description IOx
ip address 192.168.1.1 255.255.255.0
ipv6 address autoconfig
ipv6 enable
ip nat inside
ip virtual-reassembly in
duplex auto
speed auto
iox client enable interface GigabitEthernet2
```

#### 8. IED Ethernet interface:

```
interface GigabitEthernet1
description RTU
ip address 192.168.2.1 255.255.255.0
ip nat inside
ip virtual-reassembly in
duplex auto
speed auto
```

9. Serial Interface connecting to serial devices in the substation (Southbound):

```
interface Async0
no ip address
encapsulation relay-line
media-type rs232
async mode dedicated
```

The command encapsulation relay-line is used to relay the serial traffic to IOx application.

**Note:** Validation was done using RS232 based on the configuration above. Async0 can work in RS232 DCE mode and RS485 DCE Mode. Async1 can only work in RS232 DTE mode.

10. Serial relay configuration:

```
line 1
exec-timeout 0 0
no exec
transport preferred none
transport input all
transport output none
stopbits 1
```

**Note:** Async0 and Async1 reserve line 1/5 and 1/6, respectively, to relay serial data to the corresponding GuestOS /dev/ttyS1 and /dev/ttyS2.

Serial Relay Line allows Serial ports to pass traffic directly to the Guest OS:

relay line 1 1/5 propagation relay line 2 1/6 propagation

**Note:** Propagation options allow the baudrate, databits, stopbits, and parity propagation from Guest OS. If propagation is present, the control parameters will be passed from the Guest OS to the IOS physical port.

#### Figure 8 Serial Interface: IR8x9 IOx–IOxVM



11. IOS NAT:

Static NAT or Interface overload needs to be configured:

ip nat inside source static 192.168.1.250 10.10.70.250

In this example, 192.168.1.250 is the Guest OS IP address. We are doing Static NAT to convert into a public routable IP address. Fog Director uses this public IP address to identify the device.

To preserve the public IP address interface, overload can be used.

A sample configuration is shown below:

```
ip access-list standard NAT_ACL
permit 192.168.0.0 0.0.255.255
ip nat inside source list NAT_ACL interface gigabitEthernet0 overload
```

### Figure 9 NAT: IOxVM Network Interfaces



**12.** iOx NAT:

The app obtains the IP address from a DHCP server within iOx. iOx then assigns the outside port numbers if the application is deployed in NAT mode.

iOx should be configured in NAT mode for docker container applications.

The port required by application should be specified in the YAML file. For the ES200 Virtual RTU application, the Port 1731 needs to opened up.

13. LTE Backhaul and Network Layer Encryption:

Please refer to the Cisco IR800 Integrated Services Router Software Configuration Guide at the following URL:

- https://www.cisco.com/c/en/us/td/docs/routers/access/800/829/software/configuration/guide/IR800config.pdf

## Cisco IR1101 Prerequisites

## IR1101 Virtual Port Group Mapping for IOx

The VirtualPortGroup interface connects the application hosting network to the IOS routing domain. The Layer 3 interface of the application receives routed traffic from IOS. The VirtualPortGroup interface connects through the SVC Bridge to the container/application interface.

Figure 10 helps to understand the relationship between the VirtualPortGroup and other interfaces, since it is different from IR8x9 routers.

Note: IR1101 uses VirtualPortGroup to communicate with Edge Compute application, instead of Gi2 interface as in IR8x9 routers.

#### Figure 10 VirtualPortGroup Mapping



## Image and Upgrade Details

**Note:** Cisco IR1101 should be running with a minimum 16.12.01 version to support the IOx application. For details, please refer to the *Release Notes for Cisco IR1101 Industrial Integrated Services Router, Cisco IOS XE Gibraltar 16.12.x* at the following URL:

- https://www.cisco.com/c/en/us/td/docs/routers/access/1101/release/IR1101-release-notes-16-12-1.html
- 1. Download and copy the Cisco IR1101 IOS-XE image to the Cisco IR1101 flash drive.
- 2. Enter global configuration:

```
IR1101- FCWXXXXXX # configure terminal
IR1101- FCWXXXXXXX (config) #
```

#### 3. Delete all entries in the bootable image list:

```
IR1101- FCWxxxxxxx (config) # no boot system
```

4. Configure boot system variable:

IR1101- FCWxxxxxxx (config) # boot system bootflash:<system-image-filename.bin>

5. Save the configuration:

IR1101- FCWxxxxxxx # write memory

6. Reload the device:

IR1101- FCWxxxxxxx # reload

7. After the device restarted with the latest image, verify the IOx service status using the following command:

IR1101-FCWxxxxxx#sh iox-service detail

IOx service (IOxman) : Running Libvirtd : Running

Verify that CAF and IOxman services are in running state.

8. Make sure you have the correct licenses:

IR1101-FCWxxxxxx#show license udi UDI: PID:IR1101-K9,SN:FCWxxxxxxx

9. WAN interface configuration for Northbound communication towards the DSO Control Center:

```
interface VirtualPortGroup0
  ip address 192.168.0.1 255.255.255.0
  ip nat inside
  !
  interface GigabitEthernet0/0/0
  ip address dhcp
  ip nbar protocol-discovery
  ip nat outside
```

#### 10. IED Ethernet interface:

```
interfaceFastEthernet0/0/1
   switchport access vlan 2
   switchport mode access
interface Vlan2
```

```
ip address 192.168.2.1 255.255.255.0
```

11. Serial Interface connecting to serial devices in the substation (Southbound):

interface Async0/2/0
 no ip address
 encapsulation relay-line

#### 12. Serial relay configuration:

```
line con 0
exec-timeout 0 0
stopbits 1
speed 115200
line 0/0/0
transport preferred none
 transport output none
stopbits 1
line 0/2/0
transport preferred none
transport input all
transport output all
stopbits 1
line vty 0 4
 login local
 transport input all
 transport output all
Т
relay line 0/0/0 0/2/0
```

**Note:** Validation was done using RS232 based on the configuration above on interface Async0. On IR1101, *line 0/2/0* is the same as *line 50*.

## **Cisco Fog Director**

**Note:** Fog Director features are integrated into the latest Cisco IOT FND. For the purpose of validation, we have used Fog Director for IR8x9 and IOx Local Manager WebUI for IR1101. The Cisco IOT FND version was not available during the implementation phase of this document.

For more details on Cisco IOT FND, refer to the following URL:

https://www.cisco.com/c/en/us/products/cloud-systems-management/iot-field-network-director/index.html?dtid=o sscdc000283

## How to Install Cisco Fog Director

To install the Cisco Fog Director, please refer to the *Cisco Fog Director Reference Guide, Release 1.8* at the following URL:

https://www.cisco.com/c/en/us/td/docs/routers/access/800/software/guides/iox/fog-director/reference-guide/1-8 /fog\_director\_ref\_guide.html

The recommended version is 1.3 and above.

#### Figure 11 Cisco Fog Director Version

uluilu cisco.	og Director	APPS	DEVICES	CARTRIDGES	SETT	NGS	ტ
Settings Ext	tensions						Settings
	About Fog Director					Logging Configuraion	
	API Version	: 1.0				Collect Debug Logs: Yes No	
	Release Version Built On	: 1.3.0 : 28 Mar 2017	02:30:11			DOWNLOAD LOGS	
	End User License Ag	reement				Fog Portal Configuration	
	VIEV	VEND USER LICE	INSE AGREEMEN	T		Polling Frequency [Minutes]: 1440	
						APPLY Last Fog Portal sync with these settings: 19 hours back	

## Adding Cisco IR809 Secondary Substation Router into Fog Director

1. From Devices, click **Add**, as shown in Figure 12, and then enter the relevant details for devices such as IP address and port:

Figure 12 Adding Cisco IR809 in Fog Director

ulu cıs	co.	Director	APPS	DEVICES	CARTRIDGES	SETTINGS			
Dev	ices								Devices
Last H	leard : 1		1				Reachability : 1	1	
Top !	5 Consumers (To	iday)							
	Add New Devi	ce			×	b	0mb		208478452kb
	IP Address Enter IP Add	ress	Port 8443						
	Username Enter User N	ame	Password Enter F	Password		Disk		Network	
Ľ	Tags Enter new tag							Search Hostname, IP Addro	ess
C	Contact Details		Network E	lement ID				Show: All Tags	
	Contact deta	ils	Netwo	rk Element ID			CAPACITY	LAST HEARD	
	Description Description					E_ECApp_× Eximprod × es200_alid × er new tag	<b>G</b> 🛛	1 minute back	
								Device unreachable : Fai SSL connection	led to create
R		SAVE	& CLOSE	SAVE & ADD M	CANCEL				1 - 2 of 2 items

2. Once the device is added successfully, you can verify the last heard status using the option shown in Figure 13.

IIIII Fog Director	APPS DEVICES	CARTRIDGES SE	TTINGS			ტ
Devices						Devices
Last Heard : 1			F	Reachability : 1		
Top 5 Consumers (Today)						
0%		4212kb		Omb		208478452kb
CPU	,	Memory	Disk		Network	
ADD IMPORT				Se	earch Hostname, IP Ado	dress
Device Filters					Show: All Tags	
HOST NAME	IP ADDRESS	TAGS		CAPACITY	LAST HEARD	
A DEMO1-89-250	10.10.70.250	es200_Test × SCE_ECA es200_inov × Enter ner	pp_× Eximprod × es200_alld × w tag	<b>G</b> 🛛	3 minutes back	
H - 1 - H 10 - iter	ns per page					1 - 1 of 1 items

#### Figure 13 Device Status

## IOx Application Types

For this document's purpose, two types of IOx application are used for the two different platform architectures:

- For IR8x9 platform (x86 architecture), Docker style container application is used for validation, and
- For IR1101 platform (ARM64v8 architecture), LXC/Platform as a service (PaaS) style container application is used for validation. IR1101 is a bit different in comparison with most other IOx platforms as these are mainly x86 based. The IR1101 is based on the ARM64v8 architecture so you cannot deploy containers or IOx packages built for x86 on the platform directly.

For information on different styles of container applications, refer to the following URL:

https://developer.cisco.com/docs/iox/#!application-types/application-types

## Adding Docker Container ES200 Application

The Virtual RTU Docker *package.yaml* will be provided by Eximprod. Refer to the following configuration for a sample file. This file needs to be loaded on your laptop/client machine running the Cisco Fog Director client application.

Edit necessary network ports. For example, specify the Northbound ports needed by the Fog Director and device parameters (such as serial interface parameters). Port 1731 will be used by the Virtual RTU. Port 2401 is be used for Northbound communication from the Virtual RTU to Control Center communication.

```
Package.yaml file
descriptor-schema-version: "2.2"
info
  name: es200_inovium_CC_DNP3_10
  description: "IOx Docker es200 v0.9"
  version: "1.0.9"
  author-link: "http://www.inovium.ro"
  author-name: "Inovium Digital Vision"
app:
cpuarch: "x86_64"
  type: docker
  resources:
   profile: c1.small
    devices:
       device-id: serial
       label: HOST_DEV0
       type: serial
       usage: "Serial Adapter"
    network:
        interface-name: eth0
       ports:
          tcp:
           - 1731 ----- ES200 application port
            - 2401 ----- Modbus TCP
           - 20000----- DNP3 IP Port
             2404 ----- T104 port
# Specify runtime and startup
  startup:
   rootfs: rootfs.tar
    target: ["/opt/es200/initProcess.sh"]
```

## Adding a New Application

1. Click Add New App under the App tab in the Fog Director, as shown in Figure 14:

gure 14 Add Ne	w Арр				
Fog Director	APPS DE	VICES CARTRIDGES	SETTINGS		
nstalled Apps	Add new app		×		
Available Apps	You can either upload an applic create an application package f Docker Hub)	cation package created via the IOx from a Docker image present in a [	SDK, or let Fog Director oocker registry (such as the		
	Choose one: Opload from m	vy computer Create from Dock	er image	SWICHTO	APP EDIT V

2. Click the Create from Docker image checkbox listed, as shown in Figure 15.

**Note:** For applications other than Docker type, click the **Upload from my computer** checkbox from Figure 14 and jump to Publishing a Newly Added Application, page 21. For the purpose of this document:

- Docker style container application is used for IR809 validation
- Linux Container (LXC) style container application is used for IR1101 validation

For information on different styles of container applications, refer to the following URL:

https://developer.cisco.com/docs/iox/#!application-types/application-types

#### Figure 15 Docker Image Option

Add new app	×
You can either upload an application package created via t create an application package from a Docker image preser Docker Hub)	he IOx SDK, or let Fog Director ht in a Docker registry (such as the
Choose one: Upload from my computer OCreate from	n Docker image
Image name or ID: inovium/es200 Image f	tag: 2.1
Docker Registry: registry_hostname_or_ip_address:port	2
Registry Username: inovium 🕐	
Registry Password:	
Remember these credentials	
App descriptor and config parameter files: 🕐	
<ul> <li>Generate from Docker image</li> <li>Upload from my computer</li> </ul>	
Choose package.yaml and package_config.ini files:	BROWSE
	Selected: package.yaml 🗙
SUBMIT	

Fill in the required credentials in order to download the image from the repository and then choose the application's corresponding valid configuration file (*package. yaml*).

78389

Click **Submit** and wait for a successful application download.

-		
GISCO	APPS DEVICES CARTRIDGES SETTINGS	ტ
Installed Apps		
Available Apps		
	Add new app ×	SWITCH TO APP EDIT VIEW
	You can either upload an application package created via the IOx SDK, or let Fog Director create an application package from a Docker image present in a Docker registry (such as the Docker Hub)	
	Choose one: Upload from my computer OCreate from Docker image	
s200_inovium_CC_DNP.	Image name or ID: zatalinghenea/es200-ccdnp3 Image tag: (optional)	
	Docker Registry: registry_hostname_or_ip_address:port  ()	
es200_inovium_CC_DNP	Using saved credentials (catalinghenea). Forget them	
1.0.9	App descriptor and config parameter files: 👔	
	Generate from Docker image Upload from my computer	
Unpublished Apps	Choose package.yaml and package_config.ini files: BROWSE	
	Selected: package.yaml 🗙	ADD NEW APP

### Figure 16 Docker Image Details

## Publishing a Newly Added Application

After successful application download, the application is ready to be published, as shown in Figure 17:

Fog Director	APPS DEVICES CARTRIDGES SETTINGS	ტ
	es200_Test_123	es200_Test_123 App > es200_Test_123 > Configuration
es200_Test_123	es200_Test_123 Latest version: 1.0 Last updated on: Oct 26, 2017 12:00:32 PM Docker Image name: inovium/se200 Docker Image tag: 2.1 Docker Registry: Docker Hub	UPGRADE PKG PUBLISH SAVE
uthor : Inovium Digital Vision Jesource Profile : c1.small	Description Edit IOX Docker es200 v1.0 Release Notes Edit	
App Type : DOCKER		
App Links 🗧	-	

Figure 17 App Publishing

After successful publication, the application is ready for installation, as shown in Figure 18:

Figure	18	App	Ready	to	Install
--------	----	-----	-------	----	---------

cisco.	Fog Director	APPS DEVICES	CARTRIDGES	SETTINGS		ტ
		es200_Test_12	23		es200_Tes App > es200_Test_123 >	configuration
	250x250	es200_T Latest version Last updated Docker Image Docker Image Docker Regis	Test_123 h: 1.0 on: Oct 26, 2017 12 e name: inovium/es2 tag: 2.1 try: Docker Hub	02:17 PM 00	INSTALL	
Author Resource Profi	: Inovium Digital Vision le : c1.small	Description 10X Docker es200 v1 Release Notes	.0			
Арр Туре	: DOCKER					0960

## Installing a Newly Published App

The application can be installed on devices of interest. As part of the installation process, those devices are chosen and the networking parameters and interfaces of the device are configured, as shown in Figure 19 and Figure 20:

sco.	Fog Director	APPS DEVICES CART	RIDGES SETTINGS				ዓ
er Devic	es				Aţ	es20	00_Test_123 st_123 > Filter Devices
u can <b>ad c</b>	d more devices from belo	w table			Search Hos	stname, IP A	ddress
					s	how : All tag	z
	Host Name	IP Address	Tags		Installed Apps		
	DEMO1-89-250	10.10.70.250	es200_Test SCE_EC	App_ Eximprod es200_all			
ADD SELI	ECTED DEVICES						
	vices: 0			Sea	irch Hostname, IP Addr	ess	
elected De		IP Address	Tags	Health	Last H	leard	Action
lected De						N	lo items to display
lected De lost Name	0 > > 5 -	items per page					
lected De lost Name	0 > > 5 <del>-</del>	items per page					

Figure 20	Add	Selected	<b>Devices</b>
-----------	-----	----------	----------------

 :Isco.	Fog Director	APPS	DEVICES	CARTRIDGI	ES SETT	INGS						ტ
ilter Devid	ces									App > (	es200 25200_Test_1	_Test_12
You can ad	d more devices from below	v table								Search Hostnam	ne, IP Add	ress
										Show :	All tags	
	Host Name	IF	P Address		Tags				Installe	d Apps		
	DEMO1-89-250	1	0.10.70.250		es200_Test	SCE_ECApp	Eximprod	es200_;	all			
ADD SEL	ECTED DEVICES								Search Hostr	name. IP Address		
Host Name		IP Address		Та	gs			Health		Last Heard		Action
DEMO1-8	9-250	10.10.70.2	50		es200_Test	SCE_ECApp_	Eximpr		<b>G</b> M	20 minute	s back	×
R R	1 > > 5 -	items per pag	ge									1 - 1 of 1 items
												NEXT >

After clicking Add Selected Devices, click Next. Modify the Resource Profile if needed, as shown in Figure 21:

<b>Figure</b>	21	<b>Resource Profile</b>	s
---------------	----	-------------------------	---

SCO. Fog Director	APPS DEVICES	CARTRIDGES	SETTINGS		ዑ
stallation Summary				<b>б</b> Арр > es200_Te	es200_Test_123 st_123 > Installation Summary
ected Devices: 1			E	Start app after installation SACH	DONE, LET'S GO
Selected Devices					
ag Selected Devices as : es200_Test					0
Host Name	IP Address		Tags	Health	Last Heard
DEMO1-89-250	10.10.70.250		es200_Test SCE_ECApp_ Eximprod	<b>@ (</b> )	20 minutes back
					1 - 1 of 1 items
Configure Resource Profiles					θ
Configure Serial Devices					
) Configure Action Plan					
Network Status					
				< BACH	DONE, LET'S GO

Networking should be set to *nat-0*, as shown in Figure 22:

Figure 22 Ne	etworking			
	CISCO	APPS DEVICES	CARTRIDGES SETTINGS	ტ
	Installation Summary			es200_Test_123 App > es200_Test_123 > Installation Summary
	Selected Devices: 1			Start app after installation BACK DONE, LET'S GO
	Selected Devices			
	Configure Resource Profiles			
	<ul> <li>Configure Networking</li> </ul>			0
	Click on a device to configure it.	Search H/	ostname, IP Address	
	Show Devices: Unallocated (1) All (1)		Show: All Tags 🗸	Preferred networks:
	и			eth0:
Hostname: DEMO1-89-250(10.10.70 Tags: es200_Test  SCE_ECApp Interface_eth0 : select.	250) Esimprod es200_alid es200_inov Static Mode		]	Network: lac-bridge0 v Mode: Static Opynamic REASSIGN NETWORKS
select.				
lox-nat0	○ Configure Serial Devices			
	Configure Action Plan			
	Network Status			
				K BACK DONE, LET'S GO

By default, Serial Device would point to *async1*, but you should change it to *async0* since the Southbound IED is connected to the async0 serial port, as shown in Figure 23.

	CISCO. Fog Director	APPS	DEVICES	CARTRIDGES	SETTINGS		
	Installation Summary					es20 App > es200_Test_123	00_Test_123 > Installation Summar
	Selected Devices: 1					Start app after installation BACK	DONE, LET'S GO
	Selected Devices						
	Onfigure Resource Profiles						
	○ Configure Networking						
	<ul> <li>Configure Serial Devices</li> </ul>						
	Click on a device to configure it.	_	Search H	ostname, IP Addre	55		
	Show Devices: Unallocated (0) All	1)		Show:	All Tags 🗸	Serial Adapter	
<ul> <li>Edit Serial D</li> <li>Hostname: Tags:</li> <li>Select Serial</li> </ul>	etails DEMO1-09-250(10.10.70.250) Edimprod [e2200_alid es200_inov] async1	rtavailable					
Port:	async1 async0						
	Network Status						
						C DACK	

#### Figure 23 Serial Device Details

A successful installation of the application will be reflected on the Cisco Fog Director portal. More details of the application will also be shown on the Cisco Fog Directory portal, as shown in Figure 24:

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Fog Director	APPS DEVICES CARTRIDGES SETTINGS	ტ
	es200_Test_123	es200_Test_123 App > es200_Test_123 > Configuration
250x250	es200_Test_123 Latest version: 10 Last updated on: Oct 26, 2017 12:02:17 PM Docker Image name: Irovium/s200 Docker Image 1ag: 2.1 Docker Registry: Docker Hub	INSTALL MONITOR APP UNINSTALL
Author : Inovium Digital Vision Resource Profile : c1.small	Installation Successful on Actions Failed on	Upgrade Required on
App Type : DOCKER	Devices Devices EDIT CONFIGURATION RETRY NOW	Devices
	App State on installed devices : Click on the series below to view devices in each sta	ate
	Description IOX Doctor ez200 v1.0 Release Notes	

## ES200 Lifecycle Management

## Stopping ES200 Docker Container Application from Fog Director

Click **Devices** to see the App running status and then click the square **Stop App** button to stop the application, as shown in Figure 25:

13 seconds back									
13 seconds back								Devices a	• DEMO1-89-25
13 seconds back				Trou	bleshooting			Launch Loca	l Manager
1.3.0.3				C	ollect Debug L	ogs:		Yes	No
				11.		_			
Python 2.7 for IR Yocto 1.7.2 for IR	800 800				VIEW DEVICE LC	GS	DOWNLOAI	D TECH SUPPORT	LOGS
CARTRIDGES OUTSTANDIN	ACTIONS		<ul> <li>view les</li> </ul>						
JMX1941X00B		CPU	1			1			
10.10.70.250		Memory							Used
8443		Disk							Available
				20.%	40.%	60 %	80.%	100.%	
				App Detai	ils				a
App Status:	RUNNING			Resource P	rofile:	c1.small			
App Type:	DOCKER			App IP:		192.168.10.	2 P	orts	
Installed on:	26 October 2017			App mac:	la da:	52:54:99:99	:00:00		
Version:	10			Serial Port	lode:	async1			
App Links:	1.0			USB Port:		asynci			
ropp carries				Cartridges	Used:				
ime									
	App Status: App Type: App Status: App Type: Last Upgrade: Version: App Links: App L	App 5tatus:         RUNNING           App 5tatus:         20 OCKER           Installed on:         20 OCKER	Python 27 for IR800 Yocks L 7.27 for IR800         CPU Memory 10.10.70.250           B443         CPU Memory Disk total           est_123         App Status: RUNNING Apo Type: DOCKER Installed on: 2 60 October 2017 Last Upgrade: 2 60 October 2017 Last Upgrade: 2 60 October 2017 Ureion: 1.0 App Links:	Python 27.2for IRBOD Vice 17.2 for IRBOD CARTIFLICES OUTSTANDING ACTIONS JMX1941X0008 10.10.70.250 8443 est_123 App Status: RUNNING App Type: DOCKER Installed on: 26 October 2017 Last Upgrade: 26 October 2017 Last Upgrade: 26 October 2017 Last Upgrade: 26 October 2017 Version: 1.0 App Links: time	Python 2.7 for IRBO Vocis 1.7.2 for IRBO Vocis 1.7.2 for IRBO MAXIP41X00B 10.10.70.250 8443 est_123 App Status: RUNNING App Deta Installed on: 26 October 2017 Installed on: 26 October 2017 Version: 1.0 App Links: Installed on: 26 October 2017 Version: 1.0 App Links: Installed on: 26 October 2017 Version: 1.0 App Links: Installed on: 26 October 2017 Installed on: 2	Pythos 27 for IBB00 Vecto 1.72 for IBB000 Vecto 1.72 for IBB000 Vecto 1.72 for IBB000	Phino 27 for IRB0 Vocis 1.72 for IRB0 Vocis 1.72 for IRB0	Python 27 for IRB00 Vice 17.2 for IRB00	Python 2.7 for IRB00 Vocto 1.7.2 for IRB00         Vector 1.7.2 for IRB00         Vector 1.7.2 for IRB00         MXX1941X00B         1.01.0.7.0.250         8443         0% 20 % 40 % 60 % 80 % 100 %         est_123         App Status:         RUNNING         App Status:         RUNNING         App Details         Resource Profile:         Last Upgrade:       26 October 2017         Last Upgrade:       1.0         App Links:       1.0         USE Port:       Carridges Used:

## Restarting the ES200 Docker Container Application from the Fog Director

Click Start App to restart the stopped application from the Fog Director, as shown in Figure 26:

A lot user   brff/1/2.54.54.200/ide/ces/57/ Visit 1/2.56 B00 Visit 1/2.56 B00 Vis	must and a limit								
CVENT CETARS       CARTROCIS         VALUE CETARS       CARTROCIS         Value       Andita Hallow         Device Cetars       Andita Hallow         Device Cetars       Device Cetars         Device Cetars       Andita Hallow         Device Cetars       Device Cetars	A Not secure   bttps://1	10.64.66.220/#/devices/577	No. 1. 1. 101. (0.000)						Ŷ
CVECTORIAS         CVENTORIA         CVECTORIAS           Vectorias         Address:         50.52.79.20         Manor           Padress:         50.52.79.20         Manor         50.52.99.60         Manor           Padress:         50.52.79.20         Manor         50.52.99.60         Manor           Padress:         50.52.99.60         60.56.80.50         50.50.00         Manor           Padress:         50.52.99.60         50.50.00         80.56.000         Manor           Padress:         50.52.99.60         50.50.00         80.56.000         Manor           Padress:         50.52.99.60         70.56.000         70.56.000         70.56.000           Padress:         Fadress:         50.500.000         70.56.000         70.56.000           Padress:         Fadress:         50.7000         70.56.000         70.56.000           Padress:         Fadress:         Fadress:         70.56.000         70.56.000           Padress:         Fadress:         Fadress:         70.56.000         70.56.000			Yocto 1.7.2 for IR800		view law				
CVCC [D1A3]     CARROCK     CARROCK </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>									
Setur Number:         #4531410008         Fill Seture           PAddress:         9433         Date         Date         Date         Fill Seture           Descriptor:         943         Date         Date         Date         Date         Fill Seture           On App Nume: es200_Inov/um_altdrp3         App State:         STOPED         Fill Seture         Date         Fill Seture           App Inter:         STOPED         Fill Seture         App State:         STOPED         Fill Seture         App State:         C           Market         STOPED         Fill Seture         App State:         C         Fill Seture         App State:         C           Market         STOPED         Fill Seture         App State:         STOPED         Fill Seture         App State:         C           Market         STOPED         Fill Seture         App State:         STOPED         Fill Seture         Fill Seture           Market         Stope:		DEVICE DETAILS CARTRID	OUTSTANDING ACTIONS						
PAdoren:     101.270/220       Part:     64.3       Decorption:     20%     40%     60%     80%       O'     App Name:     C       Margin     Decorption:     Decorption:		Serial Number:	JM0(1941X008	CPU					
Part:     B443       Dewrigston:     B %       B %     20		IP Address:	10.10.70.250	Memory				Used	
Description:         2 %         3 % <t< td=""><td></td><td>Port:</td><td>8443</td><td>Disk</td><td></td><td></td><td></td><td>Available</td><td></td></t<>		Port:	8443	Disk				Available	
App Name es200, isovium, jubiged         App Status         STOPPED Topping         App Status		Description:		0.5	20.5 40.5	60.15	100 1		
App Name: es200, Jonvium, aldrige3       App Info       App Info       App Info       App Details       App Details       App Info       App Details       App Info				0%	20 % 40 %	60.76	00 % 100 %		
App Type:         DOCUSR         App Type:         Purtis           Installar on:         24 August 2017         App mail           Installar on:         24 August 2017         Nennous Mode:           Version:         1.00         Senial Port:         appn:1           Nentown:         1.00         Senial Port:         appn:1           Nentown:         1.00         Senial Port:         appn:1		App Info			App Details			Ø	
App State:         SDPHD         Researce Profile         Chandle           App State:         SDPHD         App State:         Chandle         Chandle         Chandle         Chandle         App State:         App State:         App State:         Chandle         Chandle         Chandle         Chandle         App State:         Chandle         App State:         Chandle         App State:         Chandle         App State:         Chandle         Chandle         Chandle         App State:         Chandle		App Info			App Details			o	
Dipole         Part Mar         Andread         Part Mar         Part Mar         Part Mar           Image: Ima		App Info	Ann Dalaur (2008)D		App Details	them by		Ø	
X         Last Upgrade:         24 August 2017         Network Mode:           Version:         1.0.0         Serial Port:         ayer.C1           Not App:         Light Port:         Serial Port:         ayer.C1		App Info	App Status: STOPPED Ann Type: DOCKER		App Details Resource Profile:	c1.small Ports		Ø	
Version:         10.0         Serial Port:         anyor.1           Num Year         Appt Units:         California         California		App Info 10_inovium_alid	App Status: STOPPED App Type: DOCKER Installed op: 24 August	017	App Details Resource Profile: App IP: App max:	c1.small Ports		Ø	
Not App Links: USB Part:		App Info	App Status: STOPPED App Type: DOCKER Installed on: 24 August: Last Upsrade: 24 August:	017	App Details Resource Profile: App IP; App mac: Network Mode:	c1.mail Ports		C	
Cartridges Deed		App Info 10_inovium_allid > x	App Status: STOPPED App Type: DOCKER Installed on: 24 August: Last Upgrade: 24 August Versiee: 1.0.0	017	App Details Resource Profile: App IP: App mas: Network Mode: Serial Port:	c1.small Ports async1		C	
		App Info	App Status: STOPPED App Type: DOCKER Installed on: 24 August: Last Upgrade: 24 August: Version: 10.0 App Links:	017	App Details Resource Proble: App IP: App mat: Network Mode: Serial Port: USB Port:	c1.small Ports async1		Ø	
		App Info Billion (1997) App Info Billion (1997) App Info (1997) App Info (1997	App Status: STOPPED App Type: DOCKER Installed on: 24 August: Last Upgrade: 24 August: Version: 10.0 App Links:	017	App Details Resource Profile: App IP: App max: Network Mode: Serial Port: USB Port: Carrifuge Used:	c1.mult Ports async1		Ø	
		App Info	Age Status: STOPPED Age Type: DOCKR Installer on 24 August Lart Upgrab: 24 August Version: 100 Age Links:	017	App Details Resource Profile: App IP: App mat: Network Mode: Serial Rote: USB Port: Cartridges Used:	clamat Ports anywc1		Ø	
		App Info	Aqq Salas: STOPPED Aqu Type: DOCKE Istalief or: 24 Aquat LastUgado: 100 AqqLinas:	917 917	App Details Resource Profile: Argo Pr Argo mas: Network Mode Set all Port: USB Part: Cartridges Unet:	cLonal Ports arync1		Ø	
		App Info	Age Manot STOPPLO Age Topo: DOCKER Installed or JAngust Last Upgrade: 24 August Minister 100 Age Lines:	817	App Details Resource Profile: App IP: App mat: Network Mode Solid Prvt: Cartridges Used:	cLanull Ports anyne1		Ø	
No downtime data available		App Info	Aqq Salan: STOPPED Aqq Syne: DOCKR Installer on: 24 Aquest Last Ugerabe: 24 Aquest Unrior: 100 Aqq Linas:	017	App Details Resource Profile: App IP: App IP: Profile: Network Mode: Seal IP: USB Pro: Cartridges Unit:	cLonal Ports anyoc1		σ	
No downtime data available		App Info	App Status: STOPPED App Type: DOCRE Installed or 24August Lat Oppsde: 24August Wreise. 100 App Linas:	017	App Details Resource Pontile App IP: App max: Network Mode Serial Tors: UP IP-ce Carbridges Used:	c1amail Ports anync1		C	

## Editing Parameters from the Fog Director

Stop the App. Edit **App Settings** (Network and Serial parameters) and then click **Reconfigure Settings**, as shown in Figure 27. Then, re-start the App.

### Figure 27 Editing App Parameters

App Info							App Det	ails			0
	App St	tatus: I	RUNNIN	G			Resource	Profile:	c1.small		
inovium CC I	App Ty	vpe: [	OOCKER	2			App IP:		192.168.10.2	Ports	
	Install	ed on: 2	21 Augus	st 2017			App mac	:	52:54:99:99:0	00:00	
	Last	:	21 Augus	st 2017			Network	Mode:	NAT		
	Upgra	de:					Serial Po	rt:	async1		
	Versio	in: 1	L.O.9				USB Por	t:			
	App Li	nks:					Cartridg	es Used:			
App Downtim	e										
pp Consumption										Day	Week
CPU % Consum	ption	Mem	ory Cons	sumption (I	<b)< td=""><td>C</td><td>isk Consum</td><td>ption (MB</td><td>) Netwo</td><td>ork Consum</td><td>ption (Bytes)</td></b)<>	C	isk Consum	ption (MB	) Netwo	ork Consum	ption (Bytes)
		3500		0		1.2			30000		
		2500		- R		1			25000		0
		2000				0.6			15000		
		1500				0.4			10000		
		1000				0.2			5000		
		0				0			0		0
ATCHDOG.LOG Resource Profile:	C1.small	NFIGURA		EDIT AP	P SETTI	NGS					
Network Configuration:											
Interface_eth	0 iox-nat0	)	~								
Serial Configuration:	async0		~								
									RECONF	IGURE SET	
App Console Su	ipport								nable Debug or	tion	
To session into the	e App Console	, run the	followin	g command	d on an S	SH Cli	ent(putty, te	erminal).	mable Debug op	Yes	No

## Uninstalling ES200 Docker Container Application from the Fog Director

Stop the App. Then click **Remove App** to remove the App, as shown in Figure 28:

#### Figure 28 Removing App

App Status: STOPPED App Type: DOCKER Installed on: 21 August 2017 Last 21 August 2017 Remove App 10: c1.small App IP: Ports App mac: Serial Port: async1 USB Port: Cartridges Used:	Info			App Details	C
Inovium_CC_D     App Type:     DOCKER     App IP:     Ports       Installed on:     21 August 2017     App mac:     App mac:       Vortexade:     21 August 2017     Network Mode:       Installed on:     1.0.9     USB Port:       App Links:     Cartridges Used:		App Status	: STOPPED	Resource Profile: c1.small	
Installed on:     21 August 2017       Last     21 August 2017       Uborade:     21 August 2017       Remove App     1.0.9       App Links:     Cartridges Used:	_inovium_CC_D	App Type:	DOCKER	App IP: Ports	
K     Last     21 August 2017       Remove App     1.0.9       App Links:     Cartridges Used:		Installed or	n: 21 August 2017	App mac:	
Remove App     1.0.9       App Links:     Cartridges Used:	×	Last	21 August 2017	Network Mode:	
App Links: Cartridges Used:	Ren	nove App	100	Serial Port: async1	
App Links: Cartridges Used:		A	1.0.9	USB Port:	
		App Links:		Cartridges Used:	

## Cisco IOx Local Manager

The application management, IOx administration, and troubleshooting can also be done using the Cisco IOx Local Manager GUI when Fog Director is not available.

Cisco IOx Local Manager is a platform-specific application that is installed on a host system as part of the installation of the Cisco IOx framework on that device. It provides a web-based user interface that you can use to manage, administer, monitor, and troubleshoot apps on the host system, and to perform a variety of related activities.

For more details on IOx Local Manager, on how to configure, access the web GUI, refer to the *Cisco IOx Local Manager Reference Guide, Release 1.8* at the following URL:

https://www.cisco.com/c/en/us/td/docs/routers/access/800/software/guides/iox/lm/reference-guide/1-8/b\_iox\_lm \_ref\_guide\_1\_8/b\_iox\_lm\_ref\_guide\_1\_8\_chapter\_01.html

On the IR110, the IOx Local Manager is embedded in the IR1101 Web Management. For more details on how to use Local Manager WebUI for application hosting, refer to the *IR1101 Software Configuration Guide* at the following URL:

https://www.cisco.com/c/en/us/td/docs/routers/access/1101/software/configuration/guide/b\_IR1101config/b\_IR11 01config\_chapter\_010001.html

## SCADA Protocol Translation Use Case using Virtual RTU

This chapter provides details implementation details for the following SCADA protocol translation scenarios:

- DNP3 Serial (Southbound) to DNP3 IP (Northbound) Translation Use Case, page 30
- DNP3 IP (Southbound) to Modbus TCP (Northbound) Translation Use Case, page 42
- DNP3 IP (Southbound) to T104 (Northbound) Translation Use Case, page 52
- Reading DNP3 Southbound Data from Northbound T104 Control Center, page 56
- IEC 61850-MMS (Southbound) to DNP3 IP (Northbound) Translation Use Case, page 64
- IEC 61850-MMS (Southbound) to T104 (Northbound) Translation Use Case, page 74

For more details on SCADA, please refer to the *Cisco 1000 Series Connected Grid Routers SCADA Software Configuration Guide* at the following URL:

https://www.cisco.com/c/en/us/td/docs/routers/connectedgrid/cgr1000/1\_0/software/configuration/guide/scada/s cada1.pdf

Virtual RTU acts as a master to Southbound IEDs and, in turn, acts as a slave to the DSO SCADA Master.

## DNP3 Serial (Southbound) to DNP3 IP (Northbound) Translation Use Case

## DNP3

DNP, which was specifically developed for use in electrical utility SCADA applications, is now the dominant protocol in those systems. It is also gaining popularity in other industries, including oil & gas, water, and waste water. The DNP specification defines a large number of data types. Within each type, multiple variations may be supported. These variations may describe whether the data are sent as 16-bit or 32-bit integral values; 32-bit or 64-bit floating point values; with or without timestamps; and with or without quality indicators (flags).

## Reading Data (Inputs)

The DNP3 specification supports multiple methods of reading inputs individually or as a group. For example, multiple types of data can be encapsulated in a single message to improve efficiency. Time stamps and data quality information can also be included.

DNP3 also supports change events. By polling for change events, the master station can reduce overall traffic on the line, as only values that have changed are reported. This is commonly called Report by Exception (RBE). To further improve efficiency, DNP3 also supports unsolicited reporting. With unsolicited reporting, slave devices can send updates as values change, without having to wait for a poll from the Master.

The master station can easily process change event data (polled or unsolicited) because the report includes the data type and variation, point number, value, and (optionally) time stamp and quality indicators.

## Control Operations (Output)

DNP3 supports control operations via output object groups (Control Relay Output Blocks or CROBs and Analog Output Blocks). DNP3 output objects are also read/write; reading the output object returns the output stats (that is, the last command that was written). The actual value of the control point can be monitored via a binary or analog input.

DNP3 also supports a variety functions commonly used on control applications, such as pulsed and paired outputs.

## Implementation Details

The Cisco IR809 router is connected to an actuator or sensor in the Southbound via Ethernet and uses DNP3 as the SCADA communication protocol. Virtual RTU software does the Northbound translation to DNP3 IP since the Control Center software is running the DNP3 IP SCADA application. The Southbound DNP3 actuator is simulated using the TMW Test Harness application. The Northbound DNP3 IP SCADA software is simulated using the TMW Distributed Test Manager (DTM) application.

## Southbound DNP3 TMW Configuration

### **Channel Configuration**

The Southbound serial IED is simulated using TMW software. In this example, as shown in Figure 29 and Figure 30, the serial port COM62 with Baud Rate 19200 is connected to Async0 of Cisco IR809:

Modify DNP3 Slave							
Channel Session Next Step							
Channel Name SDNP							
Connection Type Serial C TCP/IP							
Serial Port							
Serial Port COM62 -							
Baud Rate 19200							
Advanced Settings							
Cancel Modify							
	3.763.54						
DEM01-89-250#show line							
Tty Line Typ Tx/Rx	A Modem	Roty Acc	0 AccI	Uses	Noise Ov	erruns	Int
0 0 CTY		-		· 0	0	0/0	-
* 1 1 TTY 19200/1920	0	-		- 0	0	0/0	-
* 1/5 71 TTY 19200/1920	0	-		- 0	0	0/0	-

#### Figure 29 DNP3 Channel Configuration

Async0 (line 1) has the same baud rate as the serial RTU simulator and 1/5 serial relay connecting to the Guest OS /dev/ttyS1 where the Eximprod Southbound DNP3 master application is running.

Figure 30	DNP3	<b>Advance</b>	Channel	Configuration
-----------	------	----------------	---------	---------------

	Advanced Settings		×
•	<b>≜↓</b> 🖾		
	Туре	RS232	
	UseConnectorThread	True	
	Win232Disabled	False	
4	Serial Communicatio	ns Configuration Setting	ps 🛛
	FirstCharWait	0	
	NumCharTimesBetweer	4	
	Win232baudRate	19200	
	Win232comPortName	COM62	
	Win232numDataBits	BITS_8	
	Win232numStopBits	BITS_1	
	Win232parity	NONE	
	Win232portDtrMode	ENABLE	
	Win232portMode	NONE	-
	Michanne - Amerika da	DICADLE	
Na The	<b>me</b> e name of this channel.		
	Cancel	ОК	

Make sure Parity is set to **None**, Port is configured in **DTR mode**, StopBits is **1**, and DataBits is **8**.

## Session-related Configuration

The DNP3 Southbound serial RTU simulator is configured as slave and the source and destination layers are configured as 1 and 1. The DNP3 Master will be running on ES200. Link layer addresses needs to be communicated to the Eximprod team accordingly; they will configure the Virtual RTU database. See Figure 31:

### Figure 31 DNP3 Session Configuration

Open DNP3 Slave
Channel Session Next Step
Session Name  sDNP
ink
Sauroo:
Source.
Destination: 1
Send Unsolicited Messages
Predefined Database or Device Simulator
Default Database - Change values in Data Window 🗨
Enable DNP2 Secure Authentication
Enable DNP3 Secure Authentication
Configure User Numbers and Update Keys
Test Key Wrap Algorithm
Advanced Settings
Cancel Open

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## Northbound DNP3 IP TMW Configuration

## DNP3 IP Channel Configuration

The TMW DTM software is configured in the DNP3 IP. Master mode is used to simulate Control Center SCADA software. Port 2401 is used to communicate between the DNP3 master and slave running in ES200. This port needs to be opened in IOx NAT mode, which will be defined in the *package.yaml* file. See Figure 32:

### Figure 32 DNP3 IP Channel Configuration

🐼 DNP3 Channel Editor	
Channel Advanced	
Channel Name Control Center	
Behavior All  Master  Monitor  Peer  Slave  Unknown	
Connection Type Serial  TCP/IP  TCP/IP and UDP	
Connection Properties Mode	
Client      Server	
Local Address 0.0.0.0 - Any Adaptor	-
Remote Address 10.10.70.250	
Port 2,401	1
OK	Cancel

## **DNP3 IP Session-related Configuration**

Configure the DNP3 IP Link layer address based on Virtual RTU ES200 database settings. See Figure 33:

### Figure 33 DNP3 IP Session Configuration

a MDNP Session E	ditor	
Session Advance	d	
Session Name mE	NP	
Link Layer Addre	sses	
Source 3		
Destination 4		
Unsolicted Report Disable when Enable after F	t By Exception Restart IIN received lestart IIN processing finished	
Secure Authentic	ation	
Enabled	Edit Users	
Outstation Name	SDNP Outstation	
		OK Cancel

## **DNP3 IP Advanced Settings**

AutoTimeSynclIN and AutoEnabledUsnol are advanced DNP3 IP settings, which need to be enabled; AutoIntegrityOline and AutoIntegrityRestart settings need to be disabled. Please refer to Figure 34 for details:

\$≡ <mark>A-Z</mark>	 	Q
AutoClearRestart		•
AutoDataSetRestart		
AutoDelayMeasurement		
AutoDisableUnsol		
AutoEnableUnsol		
AutoEnableUnsolClass1		
AutoEnableUnsolClass2		
AutoEnableUnsolClass3		
AutoIntegrityLocal		
AutoIntegrityOnline		
AutoIntegrityOverflow		
> AutoIntegrityRestart		
AutoIntegrityTimeout		
AutoLANTimeSyncllN		
AutoTimeSynclIN		
Austral Inconfictence		•

## Figure 34 DNP3 Advance IP Session Configuration

## Integrity Poll Use Case

The DNP3 specification supports multiple methods of reading inputs individually or as a group. An integrity poll returns data from Class 0 (known as static data), along with data from Classes 1, 2, and 3 (which will be event data). This may or may not be everything, depending on how the slave is configured.

The integrity poll retrieves all events (Class 1, 2, and 3) and static (Class 0) data from the device. It is typically sent after device restart, loss of communication, or on a periodic basis to ensure all data is accurate. This integrity poll is executed in our case from the Northbound DTM application depicted in Figure 35 and Figure 36.





Figure 36 Integrity Data Poll Class0123

🐼 Integrity Data Poll - Class 0123 — 🗆 🗙
Name: Integrity Data Poll - Class 0123
Description
The Integrity Poll retrieves all event (class 123) and static (Class 0) data from the
device. It is typically sent after device restart, loss of communication, or on a periodic
basis to ensure all data is accurate.
Command Options
Class 0 Only
Secure Authentication
llser 🔹
Use Assessing Made
Ose Aggressive Mode
Scheduler
Once     Manual     On Connect     Scheduled
Period
Apply OK Cancel

Click Apply and then click OK to initiate a poll.

Poll results for the Northbound DTM application are shown in Figure 37. Click the **Show Point List** option under the DNP3 IP Session.

#### Figure 37 DNP3 IP Point List

Point Type T	# T	Name T	Value	τ Quality τ	Timestamp T	Description T	Enabled T	Host T	Device T	Channel T	Session T
1] Binary Inputs	0		On	Online	9/1/2017 12:37:17 PM		True	DTHost	mDNP	Control Cen	mDNP
1] Binary Inputs	1		Off	Online	9/1/2017 12:37:17 PM		True	DTHost	mDNP	Control Cen	mDNP
1] Binary Inputs	2		Off	Online	9/1/2017 12:37:17 PM		True	DTHost	mDNP	Control Cen	mDNP
1] Binary Inputs	3		Off	Online	9/1/2017 12:37:17 PM		True	DTHost	mDNP	Control Cen	mDNP
1] Binary Inputs	4		Off	Online	9/1/2017 12:37:17 PM		True	DTHost	mDNP	Control Cen	mDNP
10] Binary Output Statuse:	0		On	Offline	9/1/2017 12:06:49 PM		True	DTHost	mDNP	Control Cen	mDNP
10] Binary Output Statuse:	1		On	Offline	9/1/2017 12:06:49 PM		True	DTHost	mDNP	Control Cen	mDNP
10] Binary Output Statuse:	2		On	Offline	9/1/2017 12:06:49 PM		True	DTHost	mDNP	Control Cen	mDNP
10] Binary Output Statuse:	3		On	Offline	9/1/2017 12:06:49 PM		True	DTHost	mDNP	Control Cen	mDNP
10] Binary Output Statuse:	4		On	Offline	9/1/2017 12:06:49 PM		True	DTHost	mDNP	Control Cen	mDNP
30] Analog Inputs	0		111	Online	9/1/2017 12:11:40 PM		True	DTHost	mDNP	Control Cen	mDNP
30] Analog Inputs	1		112	Online	9/1/2017 12:11:40 PM		True	DTHost	mDNP	Control Cen	mDNP
30] Analog Inputs	2		105	Online	9/1/2017 12:11:40 PM		True	DTHost	mDNP	Control Cen	mDNP
30] Analog Inputs	3		106	Online	9/1/2017 12:11:40 PM		True	DTHost	mDNP	Control Cen	mDNP
30] Analog Inputs	4		107	Online	9/1/2017 12:11:40 PM		True	DTHost	mDNP	Control Cen	mDNP

In the poll results on the Northbound simulator that are shown above, we received four register values (0, 1, 2, and 3) of binary inputs. In the Southbound IED simulator, these are mapped to register values (6, 7, 8, and 9).

Virtual RTU does the mapping of these registers, which matches the Southbound TMW application register values. Therefore, we conclude that the integrity poll is successful. See Figure 38:

😫 Data Window - "Default" View						-		×
File Options View								
∃	Channel	Session	Sector	Туре	Number	Value	Flags	1
🖻 👰 sDNP	sDNP	sDNP	N/A	[3] Double Inputs	0	off	Online	
in sonP	sDNP	sDNP	N/A	[3] Double Inputs	1	off	Online	
[1] Binary Inputs	sDNP	sDNP	N/A	[3] Double Inputs	2	off	Online	
[3] Double Inputs	sDNP	sDNP	N/A	[3] Double Inputs	3	off	Online	
[10] Binany Output Statuses	sDNP	sDNP	N/A	[3] Double Inputs	4	off	Online	
[10] Duraire Counters	sDNP	sDNP	N/A	[3] Double Inputs	5	off	Online	
[III] [20] Running Counters	sDNP	sDNP	N/A	[3] Double Inputs		on	Online	
[21] Frozen Counters	sDNP	sDNP	N/A	[3] Double Inputs	7	off	Online	
[30] Analog Inputs	sDNP	sDNP	N/A	[3] Double Inputs	8	off	Online	
[40] Analog Output Statuses	sDNP	sDNP	N/A	[3] Double Inputs	9	off	Online	
	sDNP	sDNP	N/A	[3] Double Inputs	10	off	Online	
1861 Data Set Descriptors	sDNP	sDNP	N/A	[3] Double Inputs	11	off	Online	
E [87] Data Set Present Values	sDNP	sDNP	N/A	[3] Double Inputs	12	off	Online	
[110] China Data	sDNP	sDNP	N/A	[3] Double Inputs	13	off	Online	
	sDNP	sDNP	N/A	[3] Double Inputs	14	off	Online	
	sDNP	sDNP	N/A	[3] Double Inputs	15	off	Online	
	sDNP	sDNP	N/A	[3] Double Inputs	16	off	Online	
	SDNP	sDNP	N/A	[3] Double Inputs	17	off	Online	

#### Figure 38 DNP3 IP Input Registers

For the purposes of this document, we just discussed Binary Input register values for the Integrity poll.

## Unsolicited Reporting

DNP3 supports unsolicited reporting, which means slave devices can send updates as values change without having to wait for a poll from the master.

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In our earlier Integrity polling case, we observed that Southbound Input Register # 7 is off. Southbound Register #1 is mapped as Register #7 in the Northbound. If we change the state of the Southbound register, the Northbound register state will change automatically.
After checking the state check of Input Register #1 value @ Northbound DTM application; in this case, it is **OFF**. See Figure 39:

### Figure 39 DNP3 IP Input Registers Current Value

Point Type T	# T	Name T	Value	τ Quality τ	Timestamp T	Description	τ Enabled τ	Host T	Device T	Channel T	Session T
1] Binary Inputs	0		On	Online	9/1/2017 12:37:17 PM		True	DTHost	mDNP	Control Cen	mDNP
1] Binary Inputs	1		Off	Online	9/1/2017 12:37:17 PM		True	DTHost	mDNP	Control Cen	mDNP
1] Binary Inputs	2		Off	Online	9/1/2017 12:37:17 PM		True	DTHost	mDNP	Control Cen	mDNP
1] Binary Inputs	3		Off	Online	9/1/2017 12:37:17 PM		True	DTHost	mDNP	Control Cen	mDNP
1] Binary Inputs	4		Off	Online	9/1/2017 12:37:17 PM		True	DTHost	mDNP	Control Cen	mDNP
10] Binary Output Statuse:	0		On	Offline	9/1/2017 12:06:49 PM		True	DTHost	mDNP	Control Cen	mDNP
10] Binary Output Statuse:	1		On	Offline	9/1/2017 12:06:49 PM		True	DTHost	mDNP	Control Cen	mDNP
10] Binary Output Statuse:	2		On	Offline	9/1/2017 12:06:49 PM		True	DTHost	mDNP	Control Cen	mDNP
10] Binary Output Statuse:	3		On	Offline	9/1/2017 12:06:49 PM		True	DTHost	mDNP	Control Cen	mDNP
0] Binary Output Statuse:	4		On	Offline	9/1/2017 12:06:49 PM		True	DTHost	mDNP	Control Cen	mDNP
80] Analog Inputs	0		111	Online	9/1/2017 12:11:40 PM		True	DTHost	mDNP	Control Cen	mDNP
0] Analog Inputs	1		112	Online	9/1/2017 12:11:40 PM		True	DTHost	mDNP	Control Cen	mDNP
0] Analog Inputs	2		105	Online	9/1/2017 12:11:40 PM		True	DTHost	mDNP	Control Cen	mDNP
0] Analog Inputs	3		106	Online	9/1/2017 12:11:40 PM		True	DTHost	mDNP	Control Cen	mDNP
30] Analog Inputs	4		107	Online	9/1/2017 12:11:40 PM		True	DTHost	mDNP	Control Cen	mDNP

Now change the register # 7 value to **ON** (right click and toggle) on the Southbound application, as shown in Figure 40:

### Figure 40 DNP3 Southbound Binary Input Register Toggle

🔓 Data Window - "Default" View						_		x	
Ella Ontinua View									
File Options view									
⊡ TH Test Harness	Channel	Session	Sector	Туре	Number	Value	Flags	L ^	
🖻 👻 sDNP	sDNP	sDNP	N/A	[3] Double Inputs	0	off	Online		
	sDNP	sDNP	N/A	[3] Double Inputs	1	off	Online		
[1] Binary Inputs	sDNP	sDNP	N/A	[3] Double Inputs	2	off	Online		
[3] Double Inputs	sDNP	sDNP	N/A	[3] Double Inputs	3	off	Online		
[10] Diago Ortant Statuage	sDNP	sDNP	N/A	[3] Double Inputs	4	off	Online		
[10] Binary Output Statuses	sDNP	sDNP	N/A	[3] Double Inputs	5	off	Online		
	sDNP	sDNP	N/A	[3] Double Inputs	6	on	Online		
[21] Frozen Counters	sDNP	sDNP	N/A	[3] Double Inputs	7	off	Online		
	sDNP	sDNP	N/A	[3] Double Inputs	8	o Hide	Data Point	(s)	
[40] Analog Output Statuses	sDNP	sDNP	N/A	[3] Double Inputs	9	Chan	an DND Da	ا ماطین	ait Value(c)
	sDNP	sDNP	N/A	[3] Double Inputs	10	o	ige Dive De	uble i	/it value(s)
1861 Data Set Descriptors	sDNP	sDNP	N/A	[3] Double Inputs	11	<ul> <li>Set Fl</li> </ul>	lag(s)		
1871 Data Set Present Values	sDNP	sDNP	N/A	[3] Double Inputs	12	O Delet	- D=:=+(=)		
[110] String Data	sDNP	sDNP	N/A	[3] Double Inputs	13	oDelet	e Point(s)		
[112] Victual Terminal Output	sDNP	sDNP	N/A	[3] Double Inputs	14	off	Online		
	sDNP	sDNP	N/A	[3] Double Inputs	15	off	Online		
	sDNP	sDNP	N/A	[3] Double Inputs	16	off	Online		
	SDNP	SDNP	N/A	[3] Double Inputs	1/	off	Online		
■= AI I Modify	SDNP	sDNP	N/A	[3] Double Inputs	18	off	Online		
	SDNP	SDNP	N/A	[3] Double Inputs	19	off	Online		
<ul> <li>Configuration Settings</li> </ul>	SDNP	SDNP	N/A	[3] Double Inputs	20	off	Online		
Description	SDNP	SDNP	N/A	[3] Double Inputs	21	off	Online		
PointNumber 7	SDNP	SDNP	N/A	[3] Double Inputs	22	off	Unline		
PointType 3	SDNP	SDNP	N/A	[3] Double Inputs	23	TIO	Online		
PointTypollama Double Inpute	SDINF	-DND	NZA NZA	[3] Double Inputs	24	-"	Online		
A Mine	DNP	DNP	N/A	[3] Double Inputs [2] Double Inputs	20	off	Online		
✓ MISC	DNP	DNP	N/A	[3] Double Inputs [2] Double Inputs	20	off	Online		
Class ONE	DNP	DNP	N/A	[3] Double Inputs [3] Double Inputs	20	off	Online		
ClassString Events reported in Class 1	DNP	*DNP	N/A	[3] Double Inputs	20	off	Online		
Class	DNP	DNP	N/A	[3] Double Inputs	20	off	Online		
	DNP	DNP	N/A	[3] Double Inputs	31	off	Online		
	- Duin	DND	NU/A	[0] Double Inputs	22	"		×	
	<							> .d	

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Unsolicited reporting is observed on the Northbound application for Input register value #1.The current value is **ON**, as shown in Figure 41:

Drag a column header and drop i	t here to	group by that column										
Point Type T	# T	Name T	Value T	Quality T	Timestamp T	Description T	Enabled T	Host T	Device T	Channel T	Session T	Sector 1
[1] Binary Inputs	0		On	Online	9/1/2017 1:02:56 PM		True	DTHost	mDNP	Control Cer	mDNP	
1] Binary Inputs	1		On	Online	9/1/2017 1:02:56 PM		True	DTHost	mDNP	Control Cer	mDNP	
1] Binary Inputs	2		Off	Online	9/1/2017 1:02:56 PM		True	DTHost	mDNP	Control Cer	mDNP	
1] Binary Inputs	3		Off	Online	9/1/2017 1:02:56 PM		True	DTHost	mDNP	Control Cer	mDNP	
1] Binary Inputs	4		Off	Online	9/1/2017 1:02:56 PM		True	DTHost	mDNP	Control Cer	mDNP	
10] Binary Output Statuse:	0		On	Offline	9/1/2017 12:06:49 PM		True	DTHost	mDNP	Control Cen	mDNP	
10] Binary Output Statuse:	1		On	Offline	9/1/2017 12:06:49 PM		True	DTHost	mDNP	Control Cer	mDNP	
10] Binary Output Statuse:	2		On	Offline	9/1/2017 12:06:49 PM		True	DTHost	mDNP	Control Cer	mDNP	
10] Binary Output Statuse:	3		On	Offline	9/1/2017 12:06:49 PM		True	DTHost	mDNP	Control Cer	mDNP	
10] Binary Output Statuse:	4		On	Offline	9/1/2017 12:06:49 PM		True	DTHost	mDNP	Control Cer	mDNP	
30] Analog Inputs	0		111	Online	9/1/2017 12:37:19 PM		True	DTHost	mDNP	Control Cer	mDNP	
30] Analog Inputs	1		112	Online	9/1/2017 12:37:19 PM		True	DTHost	mDNP	Control Cer	mDNP	
30] Analog Inputs	2		105	Online	9/1/2017 12:37:19 PM		True	DTHost	mDNP	Control Cer	mDNP	
30] Analog Inputs	3		106	Online	9/1/2017 12:37:19 PM		True	DTHost	mDNP	Control Cer	mDNP	
30] Analog Inputs	4		107	Online	9/1/2017 12:37:19 PM		True	DTHost	mDNP	Control Cer	mDNP	

Figure 41 DNP3 Northbound Binary In	puts Register Changed Value
-------------------------------------	-----------------------------

### **Control Command**

In DNP3, binary output statues registers will be used for control write operations. We will try to issue a CROB command from the Northbound DTM application to Register value #1, which will then write on Register # 7 in our case. Register Value #1 on the Northbound application is mapped to Register Value #7 in the Southbound application. If we make changes on Register value #1 on the Northbound application, which is depicted in Figure 42, we will see changes reflected in the Southbound application Register value #7.

The status check on the Southbound TMW application binary output statuses Register #7 before issuing a control command from the Northbound. We can see the binary output register #7 status is **OFF** in Figure 42:

🐮 Data Window - "	Default" View					_		×
File Options	View							
∃		Channel	Session	Sector	Туре	Number	Value	Fl: /
🗄 🐌 sDNP		SDNP	sDNP	N/A	[10] Binary Output Statuses	0	Off	0
E SDNP		SDNP	sDNP	N/A	[10] Binary Output Statuses	1	Off	ŏ
	Binany Inputs	sDNP	sDNP	N/A	[10] Binary Output Statuses	2	Off	Ŏ
	Double legite	sDNP	sDNP	N/A	[10] Binary Output Statuses	3	Off	O.
	Double Inputs	sDNP	sDNP	N/A	[10] Binary Output Statuses	4	Off	O.
	Binary Output Statuses	SDNP	sDNP	N/A	[10] Binary Output Statuses	5	Off	O
	Running Counters	sDNP	sDNP	N/A	[10] Binary Output Statuses	6	Off	O
	Frozen Counters	sDNP	sDNP	N/A	[10] Binary Output Statuses	7	Off	0
[30]	Analog Inputs	sDNP	sDNP	N/A	[10] Binary Output Statuses	8	Off	O
[40]	Analog Output Statuses	sDNP	sDNP	N/A	[10] Binary Output Statuses	9	Off	Or
÷- 🗐 1851	Data Set Prototypes	sDNP	sDNP	N/A	[10] Binary Output Statuses	10	Off	Or
E [86]	Data Set Descriptors	sDNP	sDNP	N/A	[10] Binary Output Statuses	11	Off	Or
	Data Set Descriptors	sDNP	sDNP	N/A	[10] Binary Output Statuses	12	Off	Or
±	Data Set Fresent Values	sDNP	sDNP	N/A	[10] Binary Output Statuses	13	Off	Or
[110	J] String Data	sDNP	sDNP	N/A	[10] Binary Output Statuses	14	Off	Or
····· III  [112	2] Virtual Terminal Output	sDNP	sDNP	N/A	[10] Binary Output Statuses	15	Off	Or
		sDNP	sDNP	N/A	[10] Binary Output Statuses	16	Off	Or
		sDNP	sDNP	N/A	[10] Binary Output Statuses	17	Off	Or
ALL MARK	· · · ·	sDNP	sDNP	N/A	[10] Binary Output Statuses	18	Off	Or
i z↓ 🖾	пу	sDNP	sDNP	N/A	[10] Binary Output Statuses	19	Off	Or
<ul> <li>Configuration Set</li> </ul>	ttinas	sDNP	sDNP	N/A	[10] Binary Output Statuses	20	Off	Or
Description		- sDNP	sDNP	N/A	[10] Binary Output Statuses	21	Off	Or
Description	7	sDNP	sDNP	N/A	[10] Binary Output Statuses	22	Off	O
Pointivumber	/	sDNP	sDNP	N/A	[10] Binary Output Statuses	23	Off	O
PointType	10		sDNP	N/A	[10] Binary Output Statuses	24	Off	O
PointTypeName	Binary Output Statuses	sDNP	sDNP	N/A	[10] Binary Output Statuses	25	Off	O
<ul> <li>Misc</li> </ul>		sDNP	sDNP	N/A	[10] Binary Output Statuses	26	Off	Or
Class	NONE	sDNP	sDNP	N/A	[10] Binary Output Statuses	27	Off	O
ClassString		↓   sDNP	sDNP	N/A	[10] Binary Output Statuses	28	Off	Or
		sDNP	sDNP	N/A	[10] Binary Output Statuses	29	Off	O
lass		sDNP	sDNP	N/A	[10] Binary Output Statuses	30	Off	O
		sDNP	sDNP	N/A	[10] Binary Output Statuses	31	Off	O
		200	D.LID	N1 / N	1101.0		01	<u></u>

#### Figure 42 DNP3 Southbound Binary Output Statues Register #7

Now we will issue a command from the Northbound simulator to change the state of the register to **ON**.

le Tools InSight Views V	Vindov	vs	Help					
i 🖉 😭 😺 📔 🖓 📴 💽	%	1	<u> </u>					
/orkspace 🔹	, ų	×	Points - /m	DNP/	/mDNP/mD	NP		
🗗 🚛 DTM - ashok-VirtualRTU 🛛	J-26-J	uly	Drag a colu	mn he	ader and drop	it here to	group by that colum	n
mDNP			Poir	nt Typ	oe T	# T	Name	τ
			[1] Binary	Input	is.	0		Of
			[1] Binary	Input	s	1		On
			[1] Binary	Input	s	2		Of
		Man	age 🕨	Input	s	3		Of
	1	Shov	N ►	Bit I	nputs	0		Of
		Com	imands 🕨		Integrity D	Data Pol	- Class 0123	Or
	1	Simu	ulate		RBE Data	Poll - Ev	ent Class 123	Of
			[3] Double		Read Spec	ific Dat	аТуре	On
			[10] Binary		Control Re	elay Out	put Block	Or
			[10] Binaŋ		Analog Ou	utput Bl	ock	Or
			[10] Binaŋ		Time Sync	hroniza	tion	Or
			[10] Binan		Clear Rest	art IIN		Or
			[30] Analo		Enable Un	solicited	Messages	0
			[30] Analo		Data Set C	Commar	d	0
			[30] Analo	g inp	uts	2		0
		- 1	[30] Analo	g Inp	outs	3		0

### Figure 43 DNP3 IP Northbound Control Command

Figure 44	DNP3 IP	Northbound	<b>CROB</b>	Control	Command
-----------	---------	------------	-------------	---------	---------

Control Relay (	Dutput Block			• 💌
ame: Control Ro Description he remote devi- points in the sam ime.	e may support binary o e may support binary o e message, but all point	utput control operatio ts are not required to c	ns to multiple data change at the same	
Command Optic	ns			
lode: Direct	*	Qualifier Code: Sixte	eenBitIndex	-
Control Inform	ation			
Point Number:	1			
Control Code:	LatchOn			•
Pulse On Time:	100			
Feedback Pol	Delay	Before Sending 100		
User				-
Use Ag	gressive Mode			
Scheduler Once Period	Manual O On Conne	cct Scheduled		
		Apply	ОК	Cancel

Command LatchOn is executed on Point Number 1 in Figure 44 above. Mode is direct. Control Code is LatchOn.

Click **Apply** and then click **OK** to execute the command from the Northbound DTM application.

Binary Output Statuses Register # 7 value on the Southbound TMW application are changed from **OFF** to **ON**; this is depicted in Figure 45:

🔓 Data Window - "D	efault" View						-		×
File Options Vi	ew								
Test Harness		Channe	I Session	Sector	Туре	Number	Value	Flags	^
🗄 🛯 🧶 sDNP		<sup>3</sup> sDNP	sDNP	N/A	[10] Binary Output Statuses	0	Off	Online	
		sDNP	sDNP	N/A	[10] Binary Output Statuses	1	Off	Online	
	nary Inputs	sDNP	sDNP	N/A	[10] Binary Output Statuses	2	Off	Online	
I3 D	puble inputs	sDNP	sDNP	N/A	[10] Binary Output Statuses	3	Off	Online	
	Disper Output Statuese	sDNP	sDNP	N/A	[10] Binary Output Statuses	4	Off	Online	
	Sinary Output Statuses	sDNP	sDNP	N/A	[10] Binary Output Statuses	5	Off	Online	
	Nunning Counters	sDNP	sDNP	N/A	[10] Binary Output Statuses	6	Off	Online	
[21] F	rozen Counters	sDNP	sDNP	N/A	[10] Binary Output Statuses	7	On	Online	
==  [30] A	Analog Inputs	sDNP	sDNP	N/A	[10] Binary Output Statuses	8	Off	Online	
	Analog Output Statuses	sDNP	sDNP	N/A	[10] Binary Output Statuses	9	Off	Online	
😟 💷 😥 🗄	Data Set Prototypes	sDNP	sDNP	N/A	[10] Binary Output Statuses	10	Off	Online	
	Data Set Descriptors	sDNP	sDNP	N/A	[10] Binary Output Statuses	11	Off	Online	
	) ata Set Present Values	sDNP	sDNP	N/A	[10] Binary Output Statuses	12	Off	Online	
	String Data	sDNP	sDNP	N/A	[10] Binary Output Statuses	13	Off	Online	
	Surrig Data	sDNP	sDNP	N/A	[10] Binary Output Statuses	14	Off	Online	
·····[III] [112]	Virtual Terminal Output	sDNP	sDNP	N/A	[10] Binary Output Statuses	15	Off	Online	
		sDNP	sDNP	N/A	[10] Binary Output Statuses	16	Off	Online	
Bas A   Deal Modifi	iv.	sDNP	sDNP	N/A	[10] Binary Output Statuses	17	Off	Online	
	7	sDNP	sDNP	N/A	[10] Binary Output Statuses	18	Off	Online	
<ul> <li>Configuration Setti</li> </ul>	ngs	▲ sDNP	sDNP	N/A	[10] Binary Output Statuses	19	Off	Online	
Description		s DNP	sDNP	N/A	[10] Binary Output Statuses	20	Off	Online	
PointNumber	7	sDNP	sDNP	N/A	[10] Binary Output Statuses	21	Off	Online	
PointType	10	sDNP	sDNP	N/A	[10] Binary Output Statuses	22	Off	Online	
DeintType	Disease Outsuit Statuage	sDNP	sDNP	N/A	[10] Binary Output Statuses	23	Off	Online	
Forniti ypelvame	binary Output Statuses	sDNP	sDNP	N/A	[10] Binary Output Statuses	24	Off	Online	
✓ Misc		sDNP	sDNP	N/A	[10] Binary Output Statuses	25	Off	Online	
Class	NONE	SDNP	sDNP	N/A	[10] Binary Output Statuses	26	Off	Online	
ClassString		▼ sDNP	sDNP	N/A	[10] Binary Output Statuses	27	Off	Online	
Class		sDNP	sDNP	N/A	[10] Binary Output Statuses	28	Off	Online	
01000		sDNP	sDNP	N/A	[10] Binary Output Statuses	29	Off	Online	
		SDNP	sDNP	N/A	[10] Binary Output Statuses	30	Off	Online	~
		<							>:

Figure 45 DNP3 Southbound Register Value Changed to ON

# DNP3 IP (Southbound) to Modbus TCP (Northbound) Translation Use Case

The Cisco IR809 router is connected to an actuator or sensor in the Southbound via Ethernet and DNP3 IP is the SCADA communication protocol. Virtual RTU software does the Northbound translation to Modbus IP since the Control Center software is running the Modbus IP SCADA application.

- The Southbound DNP3 IP actuator is simulated using the TMW Test Harness application.
- The Northbound Modbus IP SCADA software is simulated using the TMW DTM application.

# Southbound DNP3 IP TMW Configuration

# **Channel Configuration**

The Southbound Ethernet IED is simulated using the TMW Test Harness software. In this example, Port 20000 is used for communication between the Southbound IED and the Virtual RTU ES200. See Figure 46:

Modify DNP3 Slave	
Channel Session Next Step	
Channel Name sDNP	
Connection Type	
C Serial	
TCP/IP Parameters	
Host	
Port 20000 ÷	
Local IP 0.0.0.0	-
	Advanced Settings
Cancel	Modify

### Session Configuration

The DNP3 Southbound Ethernet simulator is configured as the slave and source and destination layers are configured as **1** and **1**. The DNP3 Master will be running on ES200. The Link Layer addresses needs to be communicated to the Eximprod team and the Virtual RTU database will be configured accordingly. See Figure 47:

### Figure 47 DNP3 Southbound DNP3 IP Configuration 2

Modify DNP3 Slave						
Channel Session Next Step						
Session Name sDNP						
Source: 1						
Destination: 1						
Send Unsolicited Messages     Predefined Database or Device Simulator						
No Modification to Database	-					
Enable DNP3 Secure Authentication     Configure User Numbers and Update Keys     Toot Key Marce Macrithm						
A	dvanced Settings					
Cancel	Modify					
	6					

# Northbound Modbus TCP TMW Configuration

### **Channel Configuration**

The Northbound Ethernet SCADA Control Center is simulated using DTM software. In this example, Port 2401 is used for communication between the Northbound Control Center and Virtual RTU ES200. See Figure 48:

### Figure 48 Northbound Modbus TCP Configuration

🕼 Modbus Channel Editor 👘 💼 💼	
Channel Advanced	
Channel Name mMB	1
Behavior All      Master      Monitor      Peer      Slave      Unknown	
Connection Type ◎ ASCII ◎ RTU ◎ TCP/IP ◎ Modbus Plus	
Connection Properties Mode	
Client      Server	
Local Address 0.0.0.0 - Any Adaptor 🔹	
Remote Address 10.10.70.250	
Port 2,401	
OK Cancel	

## Virtual RTU ES200

Use the following command to ensure that the corresponding applications are running:

DEM01-89-250-GOS-1:~# ps -aux   grep es200			
root 1188 0.1 0.5 35348 5472 ?	Ss	Sep27	1:01 /opt/es200/Watchdog -d
root 1232 1.1 0.6 38416 5956 ?	Ss	Sep27	10:53 /opt/es200/ModbusSlave -c 3 -s
/opt/es200/db/racdb.db -L0 -d -11			
root 1253 0.0 0.6 40916 6060 ?	Ss	Sep27	0:00 /opt/es200/ESRemote -s
/opt/es200/db/racdb.db -L2 -d -11			
root 1262 0.8 0.5 34712 5324 ?	Ss	Sep27	8:37 /opt/es200/MultiDataMaster -s
/opt/es200/db/racdb.db -L2 -d -l1 -i			
root 1305 1.3 0.6 36876 6260 ?	Ss	Sep27	13:31 /opt/es200/ModbusMaster -c 1 -s
/opt/es200/db/racdb.db -L0 -d -l1 -i			
root 2924 0.5 0.6 36520 5956 ?	Ss	Sep27	5:45 /opt/es200/DNP3Master -c 2 -s
/opt/es200/db/racdb.db -L0 -d -l1 -i			
root 25540 0.0 0.0 4428 844 pts/0	S+	05:12	0:00 grep es200
DEM01-89-250-GOS-1:~#			

378398

# Modbus TCP (Control Center) to DNP3 IP (IED) Register Mapping

ES200 Virtual RTU software maps and translates different registers in the DNP3 IP-aware Southbound device to the Modbus TCP protocol-aware Northbound Control Center. The sample register mappings in use by the current version of ES200 application evaluated in the Connected Utilities Solutions lab are shown in Figure 49:

### Figure 49 Northbound Modbus TCP Configuration



378400

# Reading DNP3 Southbound Data from Northbound Modbus Control Center

As the register mapping depicts the InputRegister in the Northbound, the Modbus Control Center is mapped to the AnalogInput Registers in the DNP3 Southbound device. The InputRegister in the Control Center should read the corresponding AnalogInputRegister values set in the DNP3 Southbound device. See Figure 50 and Figure 51:

Northbound Control Center InputRegister 3 and 4

Nead_InputRegister	
	💯 Read — 🗆 🗙
	Name: Read_InputRegister Description Read Coils, Discrete Inputs, Holding Registers, or Input Registers Command Options Type InputRegisters Start 0
	Quantity 1 Scheduler Once Manual On Connect Scheduled Period 0   1   0   Conce Manual On Connect Apply OK Cancel



Data Window - "Default" View									-	
File Options View										
SDNP	*	Channel	Session	Sector	Туре	Number	Value	Flags	Time Updated	Descrip A
[1] Binary Inputs		sDNP	sDNP	N/A	[30] Analog Inputs	0	0	Online	27Sep17 12:46:03.590 (invalid)	
[3] Double Inputs		sDNP	sDNP	N/A	[30] Analog Inputs	1	10	Online	27Sep17 12:47:54.054 (invalid)	
[10] Binary Output Statuses		sDNP			[30] Analog Inputs			Online	27Sep17 15:17:39.060 (invalid)	
[20] Bunning Counters	=	sDNP	sDNP	N/A	[30] Analog Inputs	3	0	Online	27Sep17 12:46:03.590 (invalid)	=
[21] Emzen Countem		sDNP	sDNP	N/A	[30] Analog Inputs	4	0	Online	27Sep17 12:46:03.590 (invalid)	
[III] [21] Hozen Counters		sDNP	sDNP	N/A	[30] Analog Inputs	5	0	Online	27Sep17 12:46:03.590 (invalid)	
[30] Analog Inputs		sDNP	sDNP	N/A	[30] Analog Inputs	6	0	Online	27Sep17 12:46:03.590 (invalid)	
[40] Analog Output Statuses		sDNP	sDNP	N/A	[30] Analog Inputs	7	0	Online	27Sep17 12:46:03.590 (invalid)	
[85] Data Set Prototypes	-	sDNP	sDNP	N/A	[30] Analog Inputs	8	0	Online	27Sep17 12:46:03.590 (invalid)	
		SDNP	sDNP	N/A	[30] Analog Inputs	9	0	Online	27Sep17 12:46:03.590 (invalid)	

The Southbound DNP3 IP IED AnalogInput 1 and 2 register values are translated to Modbus TCP. We could observe that register values are matching in the Northbound Control Center application.

# Unsolicited Reporting

The DNP3 protocol supports unsolicited reporting. Slave devices send updates as values change, without having to wait for a poll from the master.

In Figure 52 and Figure 53, we are changing the BinaryInput Register 1 and 2 in the Southbound application and checking that the state of DiscreteInputRegister 3 and 4 values at Northbound DTM application are dynamically updated.

#### Figure 52 Present Value at Southbound

ង្ហែ Data Window - "Default" View										
File Options View										
	*	Channel	Session	Sector	Туре	Number	Value	Flags	Time Updated	
[1] Binary Inputs		sDNP	sDNP	N/A	[1] Binary Inputs	0	Off	Online	27Sep17 12:46:03.543	
[3] Double Inputs	-	sDNP	sDNP	N/A	[1] Binary Inputs	1	Off	Online	27Sep17 15:16:03.697	
[10] Binary Output Statuses			sDNP .	sDNP		<ol> <li>Binary Inputs</li> </ol>		On	Online	27Sep17 15:16:38.579
[20] Bunning Counters	=	sDNP	sDNP	N/A	[1] Binary Inputs	3	Off	Online	27Sep17 12:46:03.559	
[21] Engran Countern		sDNP	sDNP	N/A	<ol> <li>Binary Inputs</li> </ol>	4	Off	Online	27Sep17 12:46:03.559	
[21] Flozen Counters		sDNP	sDNP	N/A	<ol> <li>Binary Inputs</li> </ol>	5	Off	Online	27Sep17 12:46:03.559	
[III] [30] Analog Inputs		sDNP	sDNP	N/A	<ol> <li>Binary Inputs</li> </ol>	6	Off	Online	27Sep17 12:46:03.559	
[ [40] Analog Output Statuses		SDNP	SDNP	N/A	[1] Binary Innuts	7	Off	Online	27Sen17 12:46:03 559	

#### Figure 53 Present Value at Northbound

space • 4 ×	Analyzer - /mMB/mMB Poi	nts - /mMB/mMB/mMB								
📜 DTM - ashok-VirtualRTU-26-July-2017	Drag a column header and drop it here to group by that column									
mMB	Point Type 🛛 🔨	# T Name T	Value T	Quality T	Timestamp <b>T</b>					
<u>.</u>	[1] Discrete Input Registers	3	Off	N/A	9/28/2017 10:58:58 AM					
▲ Some memory memor	[1] Discrete Input Registers	4	On	N/A	9/28/2017 10:58:58 AM					
<b>2 (</b> )	[3] Input Registers	3	10	N/A	9/28/2017 10:58:58 AM					
A 2 mmb	[3] Input Registers	4	20	N/A	9/28/2017 10:58:58 AM					

### **Changing Southbound Values**

Choose BinaryInputRegister 1, right-click, and then toggle the value to **ON**, as shown in Figure 54. The earlier value was set to **OFF**.

#### Figure 54 Change Value at Southbound

📴 Data Window - "Default" View								_	
File Options View									
SDNP	<ul> <li>Channel</li> </ul>	Session	Sector	Туре	Number	Value	Flags	Time Updated	Descriptic A
[1] Binary Inputs	sDNP	sDNP	N/A	[1] Binary Inputs	0	Off	Online	27Sep17 12:46:03.543 (invalid)	
[3] Double Inputs	sDNP	sDNP	N/A	<ol><li>Binary Inputs</li></ol>		On	Online	28Sep17 06:07:08.273 (invalid)	
[10] Binary Output Statuses	sDNP	sDNP	N/A	<ol> <li>Binary Inputs</li> </ol>	2	On	Online	27Sep17 15:16:38.579 (invalid)	

### Dynamically Updated Northbound Values

See Figure 55:

### Figure 55 Register Value Changes at Northbound

Drag a column header and drop it here to group by that column													
Point Type T	#	т	Name T	Value T	Quality T	Timestamp <b>T</b>	Desc						
[1] Discrete Input Register	5 3			On	N/A	9/28/2017 11:12:28 AM							
[1] Discrete Input Register	4			On	N/A	9/28/2017 11:12:28 AM							
[3] Input Registers	3			10	N/A	9/28/2017 11:12:28 AM							
[3] Input Registers	4			20	N/A	9/28/2017 11:12:28 AM							

# **Control Command**

A status check on the Southbound TMW application Binary Output Statuses Register 1 and 2 before issuing control command from the Northbound shows that the values are set to **OFF**.

Binary Output Register 1 and 2 status is OFF, as shown in Figure 56:

### Figure 56 Register Value Changes Status at Southbound

😫 Data Window - "Default" View	Data Window - "Default" View														
File Options View															
E SES SDNP		Channel	Session	Sector	Туре	Number	Value	Flags	Time Updated						
[1] Binary Inputs		sDNP	sDNP	N/A	[10] Binary Output Statuses	0	Off	Online	27Sep17 12:46:03.574						
[3] Double Inputs		sDNP	sDNP	N/A	[10] Binary Output Statuses	1	Off	Online	27Sep17 15:18:29.636						
[10] Binary Output Statuses		sDNP	sDNP		[10] Binary Output Statuses		Off	Online	27Sep17 12:46:03.574						
[20] Bunning Counters	=	sDNP	sDNP	N/A	[10] Binary Output Statuses	3	Off	Online	27Sep17 12:46:03.574						
[21] Frazan Countam		sDNP	sDNP	N/A	[10] Binary Output Statuses	4	Off	Online	27Sep17 12:46:03.574						
Tent tool And a local		sDNP	sDNP	N/A	[10] Binary Output Statuses	5	Off	Online	27Sep17 12:46:03.574						
IIII [30] Analog Inputs		SDNP	sDNP	N/A	[10] Binary Output Statuses	6	Off	Online	27Sep17 12:46:03.574						

In the example shown in Figure 57, we tried to toggle the Southbound DNP3 values from the Northbound Control Center using Modbus. As per the register mapping, we toggled Coil Register 3 and checked the corresponding register value in the Southbound device. Present Coil Register 3 value is **OFF**.

### Figure 57 Present Coil Register 3 Value

[3] Input Registers	4	20	N/A	9/28/2017 11:44:53 AM	
[0] Coils	3	Off	N/A	9/28/2017 11:44:52 AM	
[0] Coils	4	Off	N/A	9/28/2017 11:44:52 AM	
[4] Holding Registers	1	55	N/A	9/28/2017 11:44:51 AM	378402

Changing Coil Register 3 value to **ON**, as shown in Figure 58. The Modbus TCP Command is issued on the Control Center.

mMB			Poir	nt Type	<u>τ</u>	#Τ	Name	T Value	τ Quality τ	Timestamp
		[1	1] Discret	te Inpu	t Registers	3		On	N/A	9/28/2017 11:48:45 AN
⊢ 🚆 🖏 mMB		[1	1] Discret	te Inpu	t Registers	4		On	N/A	9/28/2017 11:48:45 AM
		[3	3] Input F	Registe	rs	3		10	N/A	9/28/2017 11:48:44 AN
	Manage     Manage     Show				rs	4		20	N/A	9/28/2017 11:48:44 AN
— 📵 Read_O						3		Off	N/A	9/28/2017 11:48:44 AM
Read [	iscret Commande	•	Read	1		4		Off	N/A	9/28/2017 11:48:44 AM
- 🕒 Read J	putRegister				Descrip Write C Comm Type Index Value Schedu @ On Period	otion oils or H and Opt Coils On Ider Ider Ider	Iolding Registers       ions       Manual       Image: Contract of the second se	S On Connect	) Scheduled	• 3 m • K Cancel

Figure 58 Command to Toggle Coil Register 3 Value

Check Southbound BinaryOutputStatuses Register 1 value. As stated earlier, the Southbound has a different SCADA Protocol DNP3 IP and different register Binary Output Statuses Register 1. See Figure 59:

### Figure 59 Command to Toggle Coil Register 1 Value

ង្វែ Data Window - "Default" View									
File Options View									
	*	Channel	Session	Sector	Туре	Number	Value	Flags	Time Updated
[1] Binary Inputs		sDNP	sDNP	N/A	[10] Binary Output Statuses	0	Off	Online	27Sep17 12:46:03.574
[3] Double Inputs		sDNP	sDNP	N/A	[10] Binary Output Statuses	1	On	Online	28Sep17 06:44:03.868
[10] Binary Output Statuses		sDNP	sDNP		[10] Binary Output Statuses		Off	Online	27Sep17 12:46:03.574
[120] Running Counters	=	sDNP	sDNP	N/A	[10] Binary Output Statuses	3	Off	Online	27Sep17 12:46:03.574
[21] Frozen Counters		SDNP	sDNP	N/A	[10] Binary Output Statuses	4	Off	Online	27Sep17 12:46:03.574
Since DNP3 supports unsc	blic	ited re	porting	the N	Addbus command	center	also	reflects	s updated data

Since DNP3 supports unsolicited reporting, the Modbus command center also reflects updated data for the Coils Register 3. See Figure 60:

### Figure 60 Unsolicited Reporting at Control Center

Z DTN	/ - ashok-VirtualRTU-26-July-2017	Drag a column header and drop i	t here to	group by that column			
- 11 -	nMB	Point Type 🛛 🕇	# τ	Name T	Value T	Quality T	Timestamp T
▲ ₩ ₩B		[1] Discrete Input Registers	3		On	N/A	9/28/2017 11:52:06 AM
4 B	mMB	[1] Discrete Input Registers	4		On	N/A	9/28/2017 11:52:06 AM
	₩	[3] Input Registers	3		10	N/A	9/28/2017 11:52:06 AM
-		[3] Input Registers	4		20	N/A	9/28/2017 11:52:06 AM
	— 📵 Read_Coil	[0] Coils	3		On	N/A	9/28/2017 11:52:09 AM
	Read DiscreteInputRegister	[0] Coils	4		Off	N/A	9/28/2017 11:52:09 AM

# Present Analog Output Block Register 2 Value at Southbound

On a similar exercise to the previous one, you can try changing the DNP3 Southbound 16 bit Analog Output Block Register 1 and 2 statuses by changing the Modbus Northbound Holding Register 1 and 2. See Figure 61:

### Figure 61 Analog Output Register Present Value

te D	ata Window - "Default" View									
File	e Options View									
	Ė- <mark>999</mark> sDNP	*	Channel	Session	Sector	Туре	Number	Value	Flags	Time Updated
	[1] Binary Inputs		sDNP	sDNP	N/A	[40] Analog Output Statuses	0	0	Online	27Sep17 12:46:03.606 (
	[3] Double Inputs		sDNP	sDNP	N/A	[40] Analog Output Statuses	1	55	Online	27Sep17 15:20:58.507 (
	[10] Binary Output Statuses		sDNP	sDNP	N/A	[40] Analog Output Statuses	2	0	Online	27Sep17 12:46:03.606 (
	[20] Running Counters	Ξ.	sDNP	sDNP	N/A	[40] Analog Output Statuses	3	0	Online	27Sep17 12:46:03.606 (
	[21] Erozen Counters		sDNP	sDNP	N/A	[40] Analog Output Statuses	4	0	Online	27Sep17 12:46:03.606 (
			sDNP	sDNP	N/A	[40] Analog Output Statuses	5	0	Online	27Sep17 12:46:03.606 (m
	[III] [30] Analog Inputs		sDNP	sDNP	N/A	[40] Analog Output Statuses	6	0	Online	27Sep17 12:46:03.606 (20
	[10] [40] Analog Output Statuses		sDNP	sDNP	N/A	[40] Analog Output Statuses	7	0	Online	27Sep17 12:46:03.606 (m

# Present HoldingRegister 2 Value at Northbound

### See Figure 62:

### Figure 62 Holding Register Present Value

DTM - ashok-VirtualRTU-26-July-2017	Drag a column header and drop i	t here to g	group by that column			
mMB	Point Type 🛛 🕅	#τ	Name T	Value T	Quality T	Timestamp T
<u>u</u>	[1] Discrete Input Registers	3		On	N/A	9/28/2017 12:04:09 PM
r ≝ 🛃 mMB	[1] Discrete Input Registers	4		On	N/A	9/28/2017 12:04:09 PM
<b>2</b> • • • •	[3] Input Registers	3		10	N/A	9/28/2017 12:04:09 PM
A E mMB	[3] Input Registers	4		20	N/A	9/28/2017 12:04:09 PM
— 📵 Read_Coil	[0] Coils	3		On	N/A	9/28/2017 12:04:08 PM
Road Discrete Input Pagister	[0] Coils	4		Off	N/A	9/28/2017 12:04:08 PM
Nead_DiscreteInputKegister	[4] Holding Registers	1		55	N/A	9/28/2017 12:04:07 PM
<ul> <li>Read_HoldingRegisters</li> </ul>	[4] Holding Registers	2		0	N/A	9/28/2017 12:04:07 PM
Read_InputRegister						

# Changing Holding Register 2 Value

See Figure 63:

	J-26-July-2017	Drag	a column header and drop	it here to g	roup by that column			
MB			Point Type T	# T	Name T	Value	T Quality T	Timestamp
		[1] 0	Discrete Input Register	s 3		On	N/A	9/28/2017 12:05:21 PM
mMB		[1] 0	Discrete Input Register:	5 4		On	N/A	9/28/2017 12:05:21 PM
2 A		[3] Ir	nput Registers	3		10	N/A	9/28/2017 12:05:21 PM
	Manage 🕨	[3] Ir	nput Registers	4		20	N/A	9/28/2017 12:05:21 PN
— 📵 Read_C	Show +	[0] C	Coils	3		On	N/A	9/28/2017 12:05:21 PM
- Read D	Commands >	Read	pils	4		Off	N/A	9/28/2017 12:05:21 PN
( neud_b	Simulate	Write	olding Registers	1		55	N/A	9/28/2017 12:05:22 PN
- Read_H		[[4] P	olding Registers	2		0	N/A	9/28/2017 12:05:22 PN
			, in the second s	2 20112 01				
			Con	nmand O	ptions			
			Con	nmand O e Holdin	ptions aRegisters			•
			Con Typ Inde	nmand O e Holdin	ptions IgRegisters			2
			Con Typ Inde Valu	e Holdin	ptions IgRegisters			2 (****
			Con Typ Inde Valu	e Holdin x e	ptions IgRegisters			2 × 2
			Con Typ Inde Valu Sch:	e Holdin x e eduler Once	ptions IgRegisters	) On Connect	Scheduled	• 2 • 45 •
			Con Typ Inde Valu Sch @ Pe	nmand O e Holdin x e eduler Once riod	ptions IgRegisters	) On Connect	C Scheduled	2 (m) 45 (m)
			Con Typ Inde Valu Sch Pe	e Holdin x e e e once riod	ptions IgRegisters ◎ Manual ◎ • : 0 • :	0 On Connect	Scheduled	2 📩

Changes reflected in the Southbound Binary Output Statuses Register 2 are shown in Figure 64:

### Figure 64 Changes Reflected at Southbound Output Register

🖫 Data Window - "Default" View									
File Options View									
B SDNP	*	Channel	Session	Sector	Туре	Number	Value	Flags	Time Updated
[1] Binary Inputs		sDNP	sDNP	N/A	[40] Analog Output Statuses	0	0	Online	27Sep17 12:46:03.606
[3] Double Inputs		sDNP	sDNP	N/A	[40] Analog Output Statuses	1	55	Online	27Sep17 15:20:58.507
[10] Binary Output Statuses		sDNP	sDNP		[40] Analog Output Statuses			Online	28Sep17 07:00:37.435
[20] Running Counters	=	sDNP	sDNP	N/A	[40] Analog Output Statuses	3	0	Online	27Sep17 12:46:03.606
[21] Emzan Countern		sDNP	sDNP	N/A	[40] Analog Output Statuses	4	0	Online	27Sep17 12:46:03.606
		sDNP	sDNP	N/A	[40] Analog Output Statuses	5	0	Online	27Sep17 12:46:03.606
[30] Analog Inputs		sDNP	sDNP	N/A	[40] Analog Output Statuses	6	0	Online	27Sep17 12:46:03.606
[40] Analog Output Statuses		sDNP	sDNP	N/A	[40] Analog Output Statuses	7	0	Online	27Sep17 12:46:03.606

Unsolicited reporting in the Modbus Control Center is shown in Figure 65:

### Figure 65 Unsolicited Reporting at Modbus Control Center

DTM - ashok-VirtualRTU-26-July-2017	Drag a column header and drop i	t here to group by that column			
mMB	Point Type 🛛 🕅	# T Name T	Value T	Quality T	Timestamp <b>T</b>
	[1] Discrete Input Registers	3	On	N/A	9/28/2017 12:07:28 PM
₩ 🛃 mMB	[1] Discrete Input Registers	4	On	N/A	9/28/2017 12:07:28 PM
<b>2 1</b> 10	[3] Input Registers	3	10	N/A	9/28/2017 12:07:31 PM
	[3] Input Registers	4	20	N/A	9/28/2017 12:07:31 PM
— 📵 Read_Coil	[0] Coils	3	On	N/A	9/28/2017 12:07:30 PM
	[0] Coils	4	Off	N/A	9/28/2017 12:07:30 PM
Nead_DiscreteInputtegister	[4] Holding Registers	1	55	N/A	9/28/2017 12:07:29 PM
<ul> <li>Read_HoldingRegisters</li> </ul>	[4] Holding Registers	2	45	N/A	9/28/2017 12:07:29 PM
— 🝋 Read_InputRegister					

# DNP3 IP (Southbound) to T104 (Northbound) Translation Use Case

The Cisco IR809 router is connected to the actuator or sensor in the Southbound via Ethernet and DNP3 IP is the SCADA communication protocol. Virtual RTU software does the Northbound translation to T104 since the Control Center software is running T104 SCADA application.

- Southbound DNP3 IP Actuator is simulated using TMW Test Harness application.
- Northbound T104 SCADA Software is simulated using TMW DTM Application.

### Southbound DNP3 IP TMW Configuration

### **Channel Configuration**

Southbound Ethernet IED is simulated using the TMW Test Harness software. In this example, Port 20000 is used for communication between the Southbound IED and Virtual RTU ES200.

### Session Configuration

The DNP3 Southbound Ethernet simulator is configured as slave and the source and destination layer is configured as **1** and **1**, as shown in Figure 66. The DNP3 Master will be running on ES200. Link layer addresses needs to be communicated to the Eximprod Team and the Virtual RTU database will be configured accordingly.

Figure 66 DNP3 Southbound DNP3 IP Configuration

Modify DNP3 Slave	
Channel   Session   Next Step	
Channel Name sDNP	
Connection Type C Serial I TCP/IP	
TCP/IP Parameters	
Host	
Port 20000 ÷	
Local IP 0.0.0.0	-
	Advanced Settings
Cancel	Modify
·	

### Figure 67 DNP3 Southbound DNP3 Session Configuration

Modify DNP3 Slave
Channel Session Next Step
Session Name SDNP
Link Layer Addresses
Source:
Destination: 1
Predefined Database or Device Simulator No Modification to Database
Enable DNP3 Secure Authentication
Configure User Numbers and Update Keys
Test Key Wrap Algorithm
Advanced Settings
Modify

# Northbound T104 TMW Configuration

## **Channel Configuration**

The Northbound Ethernet SCADA Control Center is simulated using DTM software. In this example, Port 2404 is used for communication between the Northbound Control Center and the Virtual RTU ES200. See Figure 68:

10482

### Figure 68 Northbound T104 Configuration

IEC60870-5-104 Channel Editor	
Channel Advanced	
Channel Name m104	
Behavior All  Master Monitor Peer TCP/IP Parameters Mode Client Server Local Address 0.0.0.0 - Any Adaptor Remote Address 10.10.70.250	Slave Unknown
Port 2,404	(A)
Message Timeouts t1 35,000 (m) t2 10,000 (m)	Message Buffer Settings k 12 x w 8 x
t3 20,000	
Enable Redundancy	
	OK Cancel

# T104 (Control Center) to DNP3 IP (IED) Register Mapping

The ES200 Virtual RTU software maps and translates different registers in the DNP3 IP-aware Southbound device to the T104 protocol-aware Northbound Control Center. The sample register mappings in use by the current version of the ES200 application evaluated in Connected Utilities Solutions lab are shown in Figure 69:

### Figure 69 Northbound Modbus TCP Configuration



# Reading DNP3 Southbound Data from Northbound T104 Control Center

As the register mapping depicts Single Point Information in the Northbound T104 Control Center is mapped to the BinaryInput registers in the DNP3 Southbound device. Single Point Information in the Control Center should show the corresponding BinaryInput values set in the DNP3 Southbound device.

# Northbound Control Center Single Point Information 3 and 4

See Figure 70 and Figure 71:

Workspace	• 4 × Points - /m104/m104/m104/m104						2
Workspace DTM - New Workspace m104 Solution m104 Morkspace m104 Morkspace m104 Morkspace m104 Morkspace m104 Morkspace m104 Morkspace m104 Morkspace m104 Morkspace m104 Morkspace m104 Morkspace m104 Morkspace m104 Morkspace m104 Morkspace m104 Morkspace M	Drag a column header and drop it here to group I	by that column					
	Point Type	τ # τ	Name T	Value T	Quality T	Timestamp T	
	[1] Single Point Information	1		False	Invalid	10/10/2017 1:08:40 PM	
▲ § 🔊 m104	[1] Single Point Information	2		False	Invalid	10/10/2017 1:08:40 PM	
2	[1] Single Point Information	3		True	Valid	10/10/2017 1:08:40 PM	
▲ 월 S m104	[1] Single Point Information	4		False	Valid	10/10/2017 1:08:40 PM	
	[9] Measurand Value, Normalized Value	1		0	Invalid	10/10/2017 6:11:34 PM	
	[9] Measurand Value, Normalized Value	2		0	Invalid	10/10/2017 6:11:34 PM	
	[9] Measurand Value, Normalized Value	3		0	Valid	10/10/2017 6:11:34 PM	
	[9] Measurand Value, Normalized Value	4		0	Valid	10/10/2017 6:11:34 PM	
	[9] Measurand Value, Normalized Value	5		0	Valid	10/10/2017 6:11:34 PM	
	[9] Measurand Value, Normalized Value	6		0	Valid	10/10/2017 6:11:34 PM	
	[9] Measurand Value, Normalized Value	7		1	Invalid	10/10/2017 6:11:34 PM	
	[9] Measurand Value, Normalized Value	8		0	Invalid	10/10/2017 6:11:34 PM	

Figure 70 Reading Single Point Information

inguic / i obutilobulla billary inputtegister.	Figure 71	Southbound	<b>Binary</b>	InputRegisters
--	-----------	------------	---------------	----------------

皆 Data Window - "Default" View								×
File Options View								
Ė	Channel	Session	Sector	Туре	Number	Value	Flags	Tìr 🔺
	sDNP	sDNP	N/A	[1] Binary Inputs	0	Off	Online	10
[3] Double Inpu	sDNP	sDNP	N/A	[1] Binary Inputs	1	On	Online	10
[10] Binary Out ==	sDNP	sDNP		[1] Binary Inputs		Off	Online	10
[20] Running C	sDNP	sDNP	N/A	<ol><li>Binary Inputs</li></ol>	3	Off	Online	10
[21] Frozen Cor	sDNP	sDNP	N/A	<ol><li>Binary Inputs</li></ol>	4	Off	Online	10
	sDNP	sDNP	N/A	<ol> <li>Binary Inputs</li> </ol>	5	Off	Online	10
	sDNP	sDNP	N/A	<ol><li>Binary Inputs</li></ol>	6	Off	Online	10
[11] [40] Analog Ou	sDNP	sDNP	N/A	<ol><li>Binary Inputs</li></ol>	7	Off	Online	10 _
	sDNP	sDNP	N/A	<ol><li>Binary Inputs</li></ol>	8	Off	Online	10 =
4 III +	sDNP	sDNP	N/A	<ol><li>Binary Inputs</li></ol>	9	Off	Online	10
	sDNP	sDNP	N/A	<ol><li>Binary Inputs</li></ol>	10	Off	Online	10
A Modify	sDNP	sDNP	N/A	<ol><li>Binary Inputs</li></ol>	11	Off	Online	10
	SDNP	sDNP	N/A	<ol> <li>Binary Inputs</li> </ol>	12	Off	Online	10
	SDNP	SDNP	N/A	[1] Rinary Innuts	13	Off	Online	10

The Southbound DNP3 IP IED BinaryInput 1 and 2 register values are translated to T104 and we could observe register values are matching in the Northbound Control Center application.

# **Unsolicited Reporting**

DNP3 supports unsolicited reporting. Slave devices send updates as values change without having to wait for a poll from the master.

In the example shown in Figure 72 and Figure 73, we are changing the AnalogInput Register 1 and 2 in the Southbound application and checking that the state of normalized 3 and 4 values in the Northbound DTM application are dynamically updated.

#### Figure 72 Present Value at Southbound

Data Window - "Default" View						_		×
File Options View								
SDNP	*	Channel	Session	Sector	Туре	Number	Value	
[1] Binary Inputs		sDNP	sDNP	N/A	[30] Analog Inputs	0	0	
[3] Double Inputs		sDNP	sDNP	N/A	[30] Analog Inputs	1	0	
[10] Binary Output Statuses		sDNP	sDNP		[30] Analog Inputs			
[20] Bunning Counters	=	sDNP	sDNP	N/A	[30] Analog Inputs	3	0	
[21] Frazen Courtern		sDNP	sDNP	N/A	[30] Analog Inputs	4	0	=
[20] Apple a least		sDNP	sDNP	N/A	[30] Analog Inputs	5	0	
[III] [JU] Analog Inputs		sDNP	sDNP	N/A	[30] Analog Inputs	6	0	
[11] [40] Analog Output Statuses		sDNP	sDNP	N/A	[30] Analog Inputs	7	0	
[85] Data Set Prototypes		sDNP	sDNP	N/A	[30] Analog Inputs	8	0	
	-	sDNP	sDNP	N/A	[30] Analog Inputs	9	0	

### Figure 73 Present Value at Northbound

Workspace • 4 ×	Points - /m104/m104/m104/m104					
🖌 🌉 DTM - New Workspace	Drag a column header and drop it here to group by t	hat column				
m104	Point Type	<i>#</i> τ	Name T	Value T	Quality T	Timestamp T
- <u>e</u> -	[1] Single Point Information	1		False	Invalid	10/10/2017 1:08:40 PM
▲- 5 2 m104	[1] Single Point Information	2		False	Invalid	10/10/2017 1:08:40 PM
2	[1] Single Point Information	3		True	Valid	10/10/2017 1:08:40 PM
▲ Ξ 104	[1] Single Point Information	4		False	Valid	10/10/2017 1:08:40 PM
<b>m</b> 104	[9] Measurand Value, Normalized Value	1		0	Invalid	10/10/2017 6:11:34 PM
	[9] Measurand Value, Normalized Value	2		0	Invalid	10/10/2017 6:11:34 PM
	[9] Measurand Value, Normalized Value	3		0	Valid	10/10/2017 6:11:34 PM
	[9] Measurand Value, Normalized Value	4		0	Valid	10/10/2017 6:11:34 PM
	[9] Measurand Value, Normalized Value	5		0	Valid	10/10/2017 6:11:34 PM
	[9] Measurand Value, Normalized Value	6		0	Valid	10/10/2017 6:11:34 PM
	[9] Measurand Value, Normalized Value	7		1	Invalid	10/10/2017 6:11:34 PM
	[9] Measurand Value, Normalized Value	8		0	Invalid	10/10/2017 6:11:34 PM

### Changing Southbound Values

Choose AnalogInput Register 1, right-click, and then change the value of the register, as shown in Figure 74. The earlier value was set to **0**.

### Figure 74 Change Value at Southbound

a Data Window - "Default" View								x
File Options View								
B SDNP	*	Channel	Session	Sector	Туре	Number	Value	*
[1] Binary Inputs		sDNP	sDNP	N/A	[30] Analog Inputs	0	0	
[3] Double Inputs		sDNP	sDNP	N/A	[30] Analog Inputs	1	20	
[10] Binary Output Statuses		sDNP	sDNP	N/A	[30] Analog Inputs	2	0	
[20] Bunning Counters	=	sDNP	sDNP	N/A	[30] Analog Inputs	3	0	
[21] Frazen Countern		sDNP	sDNP	N/A	[30] Analog Inputs	4	0	=
[11] [21] Flozen Counters		SDNP	sDNP	N/A	[30] Analog Inputs	5	0	
[30] Analog Inputs		SDNP	sDNP	N/A	[30] Analog Inputs	6	0	
[40] Analog Output Statuses		sDNP	sDNP	N/A	[30] Analog Inputs	7	0	
[85] Data Set Prototypes		SDNP	sDNP	N/A	[30] Analog Inputs	8	0	
	Ŧ	sDNP	sDNP	N/A	[30] Analog Inputs	9	0	
		sDNP	sDNP	N/A	[30] Analog Inputs	10	0	
= A Modify		PNP	DNP	N/A	1201 Analog Inpute	11	0	

# Dynamically Updated Northbound Values

See Figure 75:



ITM - New Workspace	Drag a column header and drop it here to group by t	hat column				
m104	Point Type	Γ # T	Name T	Value T	Quality T	Timestamp T
<u> </u>	[1] Single Point Information	1		False	Invalid	10/10/2017 1:08:40 PM
- 5 m104	[1] Single Point Information	2		False	Invalid	10/10/2017 1:08:40 PM
2	[1] Single Point Information	3		True	Valid	10/10/2017 1:08:40 PM
▲ ₩ m104	[1] Single Point Information	4		False	Valid	10/10/2017 1:08:40 PM
💓 m104	[9] Measurand Value, Normalized Value	1		0	Invalid	10/10/2017 6:11:34 PM
	[9] Measurand Value, Normalized Value	2		0	Invalid	10/10/2017 6:11:34 PM
	[9] Measurand Value, Normalized Value	3		20	Valid	10/11/2017 12:10:22 PM
	[9] Measurand Value, Normalized Value	4		0	Valid	10/10/2017 6:11:34 PM
	[9] Measurand Value, Normalized Value	5		0	Valid	10/10/2017 6:11:34 PM
	[9] Measurand Value, Normalized Value	6		0	Valid	10/10/2017 6:11:34 PM
	[9] Measurand Value, Normalized Value	7		1	Invalid	10/10/2017 6:11:34 PM
	[9] Measurand Value, Normalized Value	8		0	Invalid	10/10/2017 6:11:34 PM

# **Control Command**

The status check on the Southbound TMW application Binary Output Statuses Register 1 and 2 before issuing a control command from the Northbound shows that the values are set to **OFF**. Binary output register 1 and 2 status is OFF, as shown in Figure 76:

### Figure 76 Register Value Changes Status at Southbound

ľ	🐮 Data Window - "Default" View									
	File Options View									
Γ	Ė <mark>965</mark> sDNP	*	Channel	Session	Sector	Туре	Number	Value	Flags	Time Updated
	[1] Binary Inputs		sDNP	sDNP	N/A	[10] Binary Output Statuses	0	Off	Online	27Sep17 12:46:03.574
I.	[3] Double Inputs		sDNP	sDNP	N/A	[10] Binary Output Statuses	1	Off	Online	27Sep17 15:18:29.636
	[10] Binary Output Statuses		sDNP	sDNP	N/A	[10] Binary Output Statuses		Off	Online	27Sep17 12:46:03.574
		Ξ	sDNP	sDNP	N/A	[10] Binary Output Statuses	3	Off	Online	27Sep17 12:46:03.574 ,,
	[21] Erozen Countern		sDNP	sDNP	N/A	[10] Binary Output Statuses	4	Off	Online	27Sep17 12:46:03.574
			sDNP	sDNP	N/A	[10] Binary Output Statuses	5	Off	Online	27Sep17 12:46:03.574
			sDNP	sDNP	N/A	[10] Binary Output Statuses	6	Off	Online	27Sep17 12:46:03.574

Figure 77 shows that we tried to toggle Southbound DNP3 values from the Northbound Control Center using T104. As per the register mapping, we would toggle Single Point Commands Register 3 and check the corresponding register value in the Southbound device. The present Single Point Command Register 3 value is **OFF**.

### Figure 77 Present Single Point Command Register 3 Value

[3] Input Registers	4	20	N/A	9/28/2017 11:44:53 AM	
[0] Coils	3	Off	N/A	9/28/2017 11:44:52 AM	
[0] Coils	4	Off	N/A	9/28/2017 11:44:52 AM	2
[4] Holding Registers	1	55	N/A	9/28/2017 11:44:51 AM	37843

Changing Single Point Command Register 3 value to **ON**, as shown in Figure 78. T104 Command is issued on the Control Center.

		urag a colu	nin neau	ier and orop I	chere to g	roop by that column			1
mMB		Poir	nt Type	e τ	# T	Name T	Value T	Quality T	Timestamp T
- <u>×</u> -		[1] Discret	e Inpu	t Registers	3		On	N/A	9/28/2017 11:48:45 AM
🗕 🚆 🖏 mMB		[1] Discret	e Inpu	t Registers	4		On	N/A	9/28/2017 11:48:45 AM
₩ <b>•</b> •••		[3] Input F	legiste	rs	3		10	N/A	9/28/2017 11:48:44 AM
	Manage	[3] Input F	legiste	rs	4		20	N/A	9/28/2017 11:48:44 AM
- 📵 Read_Coil	Channage P	[0] Coils			3		Off	N/A	9/28/2017 11:48:44 AM
Devel Discust	Show P		1		4		Off	N/A	9/28/2017 11:48:44 AM
Kead_Discret	Commands •	Read	Reg						Marcine Marcin
🗕 📵 Read_Holdin	Simulate	Write	Reg	🐙 Write					
				Vrite C Commi Type Index Value Schedu @ Or Period	oils or H and Opt Coils On iler ice	olding Registers	Dn Connect O Si	:heduled	3

#### Figure 78 Command to Toggle Single Point Command Register 3 Value

Figure 78 captures the control command from the Northbound application, which is configured to work in the T104 SCADA protocol. The Southbound application is configured to work in the DNP3 IP SCADA protocol. The intermediate Virtual RTU converts the T104 command into the DNP3 IP command. In this example, the Northbound Register Value 3 is mapped to the Southbound Register Value 1. We are issuing a control command to toggle the value of register from OFF to ON, which is depicted in Figure 79:

Figure 79 Command to Toggle Single Point Command Registe	ggle Single Point Command Register 1	Command to Toggle	Figure 79
--	--------------------------------------	-------------------	-----------

🔓 Data Window - "Default" View									
File Options View									
	*	Channel	Session	Sector	Туре	Number	Value	Flags	Time Updated
[1] Binary Inputs		sDNP	sDNP	N/A	[10] Binary Output Statuses	0	Off	Online	27Sep17 12:46:03.574
[3] Double Inputs		sDNP	sDNP	N/A	[10] Binary Output Statuses	1	On	Online	28Sep17 06:44:03.868
[10] Binary Output Statuses		sDNP	sDNP	N/A	[10] Binary Output Statuses		Off	Online	27Sep17 12:46:03.574 g
I201 Bunning Counters	=	sDNP	sDNP	N/A	[10] Binary Output Statuses	3	Off	Online	27Sep17 12:46:03.574
I211 Frozen Counters		sDNP	sDNP	N/A	[10] Binary Output Statuses	4	Off	Online	27Sep17 12:46:03.574

Since DNP3 supports unsolicited reporting, the T104 command center also reflects updated data for the Single Point Command Register 3. See Figure 80:

### Figure 80 Unsolicited Reporting at Control Center

📜 DT	M - ashok-VirtualRTU-26-July-2017	Drag a column header and drop i	t here to	group by that column			
- 11	mMB	Point Type 🛛 🕇	# T	Name T	Value T	Quality T	Timestamp T
<u> </u>		[1] Discrete Input Registers	3		On	N/A	9/28/2017 11:52:06 AM
4 B	mMB	[1] Discrete Input Registers	4		On	N/A	9/28/2017 11:52:06 AM
I.	2 A 10	[3] Input Registers	3		10	N/A	9/28/2017 11:52:06 AM
		[3] Input Registers	4		20	N/A	9/28/2017 11:52:06 AM
	— 📵 Read_Coil	[0] Coils	3		On	N/A	9/28/2017 11:52:09 AM
	— 🚗 Read DiscreteInputRegister	[0] Coils	4		Off	N/A	9/28/2017 11:52:09 AM

# Present Analog Output Block Register 2 Value at Southbound

On a similar exercise, one can try changing the DNP3 Southbound 16 bit Analog Output Block Register 1 and 2 statuses by changing the T104 Northbound Normalized Commands Register 1 and 2. See Figure 81:

#### Figure 81 Analog Output Register Present Value

🔓 Data Window - "Default" View									
File Options View									
	*	Channel	Session	Sector	Туре	Number	Value	Flags	Time Updated
[1] Binary Inputs		sDNP	sDNP	N/A	[40] Analog Output Statuses	0	0	Online	27Sep17 12:46:03.606 (
		sDNP	sDNP	N/A	[40] Analog Output Statuses	1	55	Online	27Sep17 15:20:58.507 (
[10] Binary Output Statuses		sDNP	sDNP	N/A	[40] Analog Output Statuses			Online	27Sep17 12:46:03.606 (
[20] Running Counters	=	sDNP	sDNP	N/A	[40] Analog Output Statuses	3	0	Online	27Sep17 12:46:03.606 (
[21] Frozen Counters		sDNP	sDNP	N/A	[40] Analog Output Statuses	4	0	Online	27Sep17 12:46:03.606 (
E (20) Applea landa		sDNP	sDNP	N/A	[40] Analog Output Statuses	5	0	Online	27Sep17 12:46:03.606 (
[30] Analog Inputs		sDNP	sDNP	N/A	[40] Analog Output Statuses	6	0	Online	27Sep17 12:46:03.606 (
[40] Analog Output Statuses		sDNP	sDNP	N/A	[40] Analog Output Statuses	7	0	Online	27Sep17 12:46:03.606 (

# Present Normalized Commands Register 2 Value at Northbound

See Figure 82:

Figure 82 Normalized C	ommands Register P	rese	ent Value			
DTM - ashok-VirtualRTU-26-July-2017	Drag a column header and drop	t here to	group by that column			
mMB	Point Type T	# T	Name T	Value T	Quality T	Timestamp <b>T</b>
······	[1] Discrete Input Registers	3		On	N/A	9/28/2017 12:04:09 PM
🖌 🚆 🖏 mMB	[1] Discrete Input Registers	4		On	N/A	9/28/2017 12:04:09 PM
<b>2</b> • • • •	[3] Input Registers	3		10	N/A	9/28/2017 12:04:09 PM
	[3] Input Registers	4		20	N/A	9/28/2017 12:04:09 PM
— 📵 Read_Coil	[0] Coils	3		On	N/A	9/28/2017 12:04:08 PM
Pood DiscrotoIoputPosists	[0] Coils	4		Off	N/A	9/28/2017 12:04:08 PM
Wead_DiscreteInputKegiste	[4] Holding Registers	1		55	N/A	9/28/2017 12:04:07 PM
Read_HoldingRegisters	[4] Holding Registers	2		0	N/A	9/28/2017 12:04:07 PM
🗕 🖲 Read_InputRegister						

# Changing Normalized Commands Register 2 Value





### Figure 83 Command to Change Normalized Commands Register Value

# Changes Reflecting in Southbound Binary Output Statuses Register 2

### See Figure 84:

### Figure 84 Changes Reflected at Southbound Output Register

😫 Data Window - "Default" View									
File Options View									
Ė 🥵 sDNP	*	Channel	Session	Sector	Туре	Number	Value	Flags	Time Updated
[1] Binary Inputs		sDNP	sDNP	N/A	[40] Analog Output Statuses	0	0	Online	27Sep17 12:46:03.606
[3] Double Inputs		sDNP	sDNP	N/A	[40] Analog Output Statuses	1	55	Online	27Sep17 15:20:58.507
[10] Binary Output Statuses		sDNP	sDNP	N/A	[40] Analog Output Statuses	2	45	Online	28Sep17 07:00:37.435
[20] Bunning Counters	=	sDNP	sDNP	N/A	[40] Analog Output Statuses	3	0	Online	27Sep17 12:46:03.606
[21] Frozen Counters		sDNP	sDNP	N/A	[40] Analog Output Statuses	4	0	Online	27Sep17 12:46:03.606
[20] Apples legits		sDNP	sDNP	N/A	[40] Analog Output Statuses	5	0	Online	27Sep17 12:46:03.606
[30] Analog Inputs		sDNP	sDNP	N/A	[40] Analog Output Statuses	6	0	Online	27Sep17 12:46:03.606
[40] Analog Output Statuses		sDNP	sDNP	N/A	[40] Analog Output Statuses	7	0	Online	27Sep17 12:46:03.606

# Unsolicited Reporting in T104 Control Center

### See Figure 85:

### Figure 85 Unsolicited Reporting at Control Center

DTM - ashok-VirtualRTU-26-July-2017	Drag a column header and drop it here to group by that column				
mMB	Point Type T	#T Name T	Value T	Quality T	Timestamp <b>T</b>
	[1] Discrete Input Registers	3	On	N/A	9/28/2017 12:07:28 PM
₩ mMB	[1] Discrete Input Registers	4	On	N/A	9/28/2017 12:07:28 PM
	[3] Input Registers	3	10	N/A	9/28/2017 12:07:31 PM
	[3] Input Registers	4	20	N/A	9/28/2017 12:07:31 PM
— 📵 Read_Coil	[0] Coils	3	On	N/A	9/28/2017 12:07:30 PM
	[0] Coils	4	Off	N/A	9/28/2017 12:07:30 PM
Wead_DiscreteInputkegister	[4] Holding Registers	1	55	N/A	9/28/2017 12:07:29 PM
<ul> <li>Read_HoldingRegisters</li> </ul>	[4] Holding Registers	2	45	N/A	9/28/2017 12:07:29 PM
- 📵 Read_InputRegister					

# IEC 61850-MMS (Southbound) to DNP3 IP (Northbound) Translation Use Case

## Implementation Details

The Cisco IoT Gateway is connected to an actuator or sensor in the Southbound via Ethernet and uses IEC 61850-MMS as the SCADA communication protocol. Virtual RTU software does the Northbound translation to DNP3 IP since the Control Center software is running the DNP3 IP SCADA application. The Southbound IEC 61850-MMS actuator is simulated using the TMW Test Harness application. The Northbound DNP3 IP SCADA software is simulated using the TMW DTM application.

### Figure 86 Implementation Details of DNP3 to IEC 61850 Translation



# Southbound IEC 61850-MMS TMW Configuration

### **Channel Configuration**

The Southbound IED is simulated using TMW software. In this example, the TMW-simulated IEC 61850-MMS IED is connected to GigabitEthernet1 of IR809 or FastEthernet0/0/1 of IR1101.



EC 61850 Server Cl	hannel Configuration		_ 🗆 ×
Basic Advanced			
Channel Name F SCL File IEC 61850 Serve specified in the s	1 rs will be instanced as Edition 1 devices unless the IED's 'originalScIVersion' and 'originalS SCL file.	SclRevision' attril	outes are
SCL File SIE	MENS-NewBox.iid		۵ 🗋
IED to Load SIE	MENS		Ŧ
Access Point P1			Ŧ
Connection Prop	erties		
Local IP Address	•	Assign IP Add	lresses
Port	102		
GOOSE Adapter	•	GOOSE Loopba	ck Enabled
		ОК	Cancel

1. Choose the appropriate deployment-specific SCL file. Then select the IED.

2. In the Advanced Configuration tab, no changes are required. Figure 88 and Figure 89 are for reference.

Figure 88	IEC 61850	Advance	Channel	Configuration
-----------	-----------	---------	---------	---------------

IEC	61850 Server Channel Configuration			□ ×
Ba	sic Advanced			
\$	A-Z			Q
Ŧ	Seven Layer Addressing			<b></b>
	Auto Data Changes			
>	Allow Auto Updates On Specific Attri			
	File Services			
	Allow Directory Listing	V		
	Allow File Delete	V		
	Allow File Download	V		
	Allow File Upload	V		
	File Services Root Directory	C:\ProgramData\Triangle MicroWorks\DTM\Files		
	Security			
	Certificate Authority Chaining Verfica	1		
	Certificate Authority File			Ť
	Certificate Authority Revocation List			Ť
	Cipher	TLSv1:ISSLv2:IaNULL:IeNULL:ICAMELLIA:IEXPORT40:IEXPORT56:@STRENGTH		
	Diffie Hellman File Name			Ť
	Directory to Certificate Authority			
	IEC 62351 Edition 1			
	MMS Common Name			
	MMS Private Key file		D	Ť
	MMS Private Key PassPhrase			
	MMS Public Certifcate File			Ť
	OpenSSLMethod	TLSV1		*
	OpenSSLOption	NOT_USED		*
	SecurityMechanism	None		*
	TLS Common Name			
	TLS Max PDU's before forcing cipher	100		
	TLS Max renegotiate wait time	0		
	TLS Private Key File		D	Ť
	TLS Private Key PassPhrase			
	TLS Public Certificate File			Ū
	TLS Renegotiation (Seconds)	1000		
	Wash-Daseword			•
		ОК	Can	cel

|--|

61850 Server Channel Configurati		_
sic Advanced		
A-Z		کر
TLS Private Key PassPhrase		
TLS Public Certificate File		D 🖬
TLS Renegotiation (Seconds)	1000	
Weak-Password		
Configuration		
Channel Name	P1	
ConnectDelay	0	
Enabled	<b>v</b>	
ForceDisconnected		
IPv6		
Online	<b>v</b>	
RxBufferSize	256	
System Frequency	60	
UseConnectorThread	~	
Win232Disabled		
Ethernet Adapters		
GOOSE Adapter		*
GOOSE Loopback	Off	*
Sampled Values Adapter		*
Sampled Values Loopback		
Basic		
IED Name		
* SCL File	SIEMENS-NewBox.iid	Din
Server AP	P1	
Server IED	SIEMENS	*
Server Specific		
Ignore SCL Control Block Settings		
Ignore SCL Services		
Connection		
Local Address	0.0.0.0	•
Maximum PDU Size	65535	
Server Port	102	
ourse for	102	

# Northbound DNP3 IP TMW Configuration

### DNP3 IP Channel Configuration

The TMW DTM software is configured in the DNP3 IP. Master mode is used to simulate Control Center SCADA software. Port 2401 is used to communicate between the DNP3 master and slave running in ES 200. This port needs to be opened in IOX NAT mode, which will be defined in the package.yaml file. See Figure 90:

### Figure 90 DNP3 IP Channel Configuration

Z IEC60870-5-104 Channel Editor	
Channel Advanced	
Channel Name m104	
Behavior O All O Master O Monitor O Peer O TCP/IP Parameters	Slave OUnknown
Mode © Client © Server	
Local Address 0.0.0.0 - Any Adaptor	-
Remote Address 10.10.70.250	
Port 2,404	
Message Timeouts	Message Buffer Settings
t1 35,000	k 12
t2 10,000	w 8
t3 20,000	
Enable Redundancy	
	OK Cancel

### DNP3 IP Session-related Configuration

Configure the DNP3 IP Link Layer address based on Virtual RTU ES200 database settings. See Figure 91:

### Figure 91 DNP3 IP Session Configuration

🐼 MDNP Session Ec	itor	
Session Advanced	ł	
Session Name mDI	NP	
Link Laver Addres	ses	
Source 3		14 15
Destination 4		(A)
Unsolicted Report	By Exception Restart IIN received estart IIN processing finished	
Secure Authentica	tion	
Enabled	Edit Users	
Outstation Name	SDNP Outstation	
	ОК	Cancel

### **DNP3 IP Advanced Settings**

AutoTimeSynclIN and AutoEnabledUnsol are advanced DNP3 IP settings, which need to be enabled; AutoIntegrityOnline and AutoIntegrityRestart settings need to be disabled. Please refer to Figure 92 for details:

MDNP Session Editor	 _		×
Session Advanced			
ta A-Z			Q
AutoClearRestart			•
AutoDataSetRestart			
AutoDelayMeasurement			
AutoDisableUnsol			
AutoEnableUnsol			
AutoEnableUnsolClass1			=
AutoEnableUnsolClass2			
AutoEnableUnsolClass3			
AutoIntegrityLocal			
AutoIntegrityOnline			
AutoIntegrityOverflow			
> AutoIntegrityRestart			
AutoIntegrityTimeout			
AutoLANTimeSyncllN			
AutoTimeSyncllN			
A			•
AutoIntegrityRestart Issue integrity data poll on restart			
	ОК	Ca	ncel

### DNP3 IP (Control Center) to IEC 61850-MMS (IED) Register Mapping

The ES200 Virtual RTU software maps and translates different registers in the IEC 61850-aware Southbound device to the DNP3 protocol-aware Northbound Control Center. The sample register mappings in use by the current version of the ES200 application evaluated in the Connected Utilities Solutions lab are shown in Figure 93:

DNP3 IP (Northbound)	IEC61850-MMS (Southbound)	Type of Register
Binary Output	OPER - ctiNum - operVal	Control Registers or Write Registers
Double Bit Input	POS - stVal - q - t	Measurement or Input Registers

### Figure 93 DNP3 to IEC 61850 Point List Mapping

Note: Contact Eximprod's team for creating/modifying the point list mapping database, at the following URL:

https://www.epg.ro/en/contact/

# Integrity Poll Use Case

The DNP3 specification supports multiple methods of reading inputs individually or as a group. An integrity poll returns data from Class 0 (known as static data), along with data from Classes 1, 2, and 3 (which will be event data). This may or may not be everything, depending on how the slave is configured.

The integrity poll retrieves all events (Class 1, 2, and 3) and static (Class 0) data from the device. It is typically sent after device restart, loss of communication, or on a periodic basis to ensure all data is accurate. This integrity poll is executed in our case from the Northbound DTM application depicted in Figure 94 and Figure 95:



### Figure 95 Integrity Data Poll Class0123

🕼 Integrity Data Poll - Class 0123 — 🗆 🗙								
Name: Integrity Data Poll - Class 0123 Description The Integrity Poll retrieves all event (class 123) and static (Class 0) data from the								
device. It is typically sent atter device restart, loss of communication, or on a periodic basis to ensure all data is accurate.								
Command Options								
Secure Authentication								
User								
Use Aggressive Mode								
Scheduler								
Once O Manual O On Connect O Scheduled								
Period $0 \div$ $0 \div$ $0 \div$								
Apply OK Cancel								

- 1. Click **Apply** and then click **OK** to initiate a poll. Poll results for the Northbound DTM application are shown in Figure 96.
- 2. Click the Show Point List option under the DNP3 IP Session.



Distributed Test Manager Administration v1.4.0.4	(127.0.0.1)- © Triangle Microworks, Inc. 20	19								σ×
File Tools Views Windows Help									0	
🕒 😂 🔓 👍 , 📖 🤫 🗂 💽 🛠 ,										
Workspace • # ×	Workspace	×	× 🖯 IED				×			
▲ 🍘 IEC61850-DNP3-01	32 07:08:09.696: IEC61850/Wri	te, Write SBOControl:SIEMENSCB1/CSW11.Pos.SBOw.T Value: 07/02/2019_07:11:30.1( )	Drag a colu	amn header and drop it here to	group by t	hat column				
- mied	33 07:08:09.696: IEC61850/Wr1 34 07:08:09.696: IEC61850/Wr1	te, Write SBOLONTFOILEST:SLEMENSCBJ/CSW11.Pos.SBOW.lest Value: False te, Write BitString:SLEMENSCBJ/CSW11.Pos.SBOW.Check Value: no-check		Path		* ¥ P	oint Type	Ŧ	Value	Ψ.*
III SIEMENS	36 07:08:09.961: IEC61850/Wri	te, Write Control OrCat Enumerated:SIEMENSCB1/CSWI1.Pos.Oper.origin.orCat Value	SIEMENS	CB1/CSWI1.Pos.Oper.ctlN	um	INT8U			1	
· · · · · · · · · · · · · · · · · · ·	37 07:08:09.961: IEC61850/Wri	te, Write SBOControlOrIdent:SIEMENSCB1/CSWI1.Pos.Oper.origin.orIdent Value: 45	SIEMENS	CB1/CSWI1.Pos.Oper.ctlV	al	BOOLE	AN		True	
9 5 - P1	39 07:08:09.961: IEC61850/Wri	te, Write UTC Time:SIEMENSCB1/CSWII.Pos.Oper.T Value: 07/02/2019 07:11:30.164,	SIEMENS	CB1/CSWI1.Pos.Oper.orig	in.orCat	Enum			remote-contr	ol
÷ 26 53	40 07:08:09.961: IEC61850/Wri	te, Write Boolean:SIEMENSCB1/CSWI1.Pos.Oper.Test Value: False	SIEMENS	CB1/CSWI1.Pos.Oper.orig	in.orldent	Octet6	4		45-53-32-30-	30
SCADA CC	41 07:08:09.961: IEC61850/Wr1 42 07:09:48.772:	te, Write BitString:SIEMENSCB1/CSWI1.Pos.Oper.Check Value: no-check	SIEMENS	CB1/CSWI1.Pos.Oper.T		Timest	amp		2019-07-02 0	7:1
?	43 07:05:48.772: ### mDNP - 10.10.32.5:20000 - TCP transmit 10 bytes			SIEMENSCR1/CSWI1 Pos Oper Test			BOOLEAN		False	
mDNP	44 07:10:03.679: 45 07:10:03 670: (114 mDMD	44 07:10:03.679: 45 07:10:03.679: <+++ mDNP Build DNP3 Message: Class Data Poll 46 07:10:03.679:			SIEMENSCB1/CSWI1.Pos.origin.orCat				remote-contr	ol
÷ 😤	46 07:10:03.679:							Octat64 45-5		
	47 07:10:03.679:	Tx Object 60(Class Data), variation 2, qualifier 0x06(All Points)	SIEMENIS	CB1/CSWI1 Por a		Quality	<i>i</i>		100000000000	100
•	49 07:10:03.679:	Tx Object 60(Class Data), variation 3, gualifier 0x06(All Points)	CIEMENSCR1/COM/1.Pos.Q			OhiPal	OhiDef		[0000000000	
- G s mDNP	50 07:10:03.679:		CIENAENIC	CB1/CSWI1.Pos.sb0		INIT22	ř		20000	
E	51 07:10:03.679:	Tx Object 60(Class Data), variation 4, qualifier 0x06(All Points)	CIENTENIC	CB1/CSWIT.Pos.Sb0Timec	at .	Charle	, ,		No. Charle	-
<ul> <li>— O Analog Output Block</li> </ul>	53 07:10:03.679:	Tx Object 60(Class Data), variation 1, qualifier 0x06(All Points)		CD1/CSWIT.POS.SBOW.Ch	PCK	Check			NO-CHECK	F
	54 07:10:03.679:	Tecort request in evenue Class Data Dall	Select Vi	ew T Displaying 2712	of 2712 da	ta points				
— 🚺 Control Relay Output B	56 07:10:03.679:	Insert request in queue. class bata Foli		entre in the second sec						
	57 07:10:03.679: <=== mDNP	Application Header, Read Request	🗑 mDN	IP						×
Integrity Data Poll - Cla	59 07:10:03.679:	FIR(1) FIR(1) CON(0) UNS(0) SEQ# 13 cd 01 3c 02 06 3c 03 06 3c 04 06 3c 01 06						_		_
	60 07:10:03.679:		Drag a colu	amn header and drop it here to	group by t	hat column				
	61 07:10:03.679: ### mDNP -	10.10.32.5:20000 - TCP transmit 27 bytes	2 T	Point Type	T - T	Value	T Quality	Ŧ	Timestam	2
	63 07:10:04.007: ===> mDNP	Application Header, Response		[1] Binary Inputs	0	Off	Offline		6/26/2019 11:	50:17
	64 07:10:04.007:	FIR(1) FIN(1) CON(0) UNS(0) SEQ# 13		[1] Binary Inputs	1	Off	Online		7/2/2019 7:10	04 AN
	65 07:10:04.007: 66 07:10:04.007:	cd 81 00 00 01 01 00 01 02 00 03 01 00 01 03 02 Ra 82 88 81 89		[1] Binary Inputs	2	Off	Online		7/2/2019 7:10	04 AN
	67 07:10:04.116:			[3] Double Bit Inputs	0	Intermediate	Offline	-	6/26/2019 11:	50-17
	68 07:10:04.116: +++> mDNP	Process response to request: Class Data Poll		[3] Double Bit Inputs	1	On	Online	-	7/2/2019 7:10	04 AN
	70 07:10:04.116:	Rx Object 1(Binary Input), variation 1, qualifier 0x00(8 Bit Start Stop)		[3] Double Bit Inputs	2	Intermediate	Online		7/2/2019 7:10	04 65
	71 07:10:04.116:	Binary Input 000001 = 0x01		[2] Double Dit Inputs	2	Intermediate	Online	_	7/2/2010 7:10	04.41
	72 07:10:04.116:	Binary Input 000002 = 0x01		[3] Double Bit Inputs	3	orr	Offine		C/2C/2019 7.10	04 AIV
	74 07:10:04.116:	Rx Object 3(Double Bit Input), variation 1, qualifier 0x00(8 Bit Start Stop		[10] Binary Output Statu	ses U	Off	Omine		0/20/2019 11:	30:177
	75 07:10:04.116:	Double Bit Input 000001 = 0x81 on		[10] Binary Output Statu	ses 1	Off	Offline		//2/2019 /:10	04 AN
	77 07:10:04.116:	Double Bit Input 000003 = 0x01 intermediate								
	78 07:10:04.116:									
	79 07:10:04.116:	Rx Object 10(Binary Output), variation 2, qualifier 0x00(8 Bit Start Stop) Binary Output 000001 = 0x00	4		_					
<	81	v								-
Workspace Resources	<	>	Select Vi	ew * Displaying 9 of 9	data poin	ts.				

In the poll results on the Northbound simulator that are shown above, we received Double Bit input register values of DNP3. In the Southbound IED simulator, these are mapped to register Pos.Oper.stVal values.

Virtual RTU reconstruct the SCADA protocol, which matches the Southbound TMW application register values. Therefore, we conclude that the integrity poll is successful.

For the purposes of this document, we just discussed Double Bit Input register values for the Integrity poll.

### **Control Command**

In DNP3, binary output statues registers will be used for control write operations. We will try to issue a CROB command from the Northbound DTM application to Boolean register on IED. IF send a control command to this Boolean register Pos.Oper.ctVal it will execute the command and also update the Double Point register Pos.Oper.stVal value of IED.

The status check on the Southbound TMW before issuing a control command from the Northbound. We can see the Boolean register Pos.Oper.ctVal status is **False** in Figure 97:

🗐 P1				×
Drag a co	lumn header and drop it here to group by	that column		
	Path * 🍸	Point Typ 🛛 🔻	Value T	*
SIEMEN	SCB1/CSWI1.Pos.Oper.ctlNum	INT8U	6	
SIEMEN	SCB1/CSWI1.Pos.Oper.ctlVal	BOOLEAN	False	
SIEMEN	SCB1/CSWI1.Pos.Oper.origin.orCat	Enum	remote-control	
SIEMEN	SCB1/CSWI1.Pos.Oper.origin.orlder	Octet64	45-53-32-30-30	
SIEMEN	SCB1/CSWI1.Pos.Oper.T	Timestamp	2019-08-24 05:18	
SIEMEN	SCB1/CSWI1.Pos.Oper.Test	BOOLEAN	False	
SIEMEN	SCB1/CSWI1.Pos.origin.orCat	Enum	remote-control	
SIEMEN	SCB1/CSWI1.Pos.origin.orldent	Octet64	45-53-32-30-30	
SIEMEN	SCB1/CSWI1.Pos.q	Quality	[000000000000]	
SIEMEN	SCB1/CSWI1.Pos.SBO	ObjRef		
SIEMEN	SCB1/CSWI1.Pos.sboTimeout	INT32U	30000	
SIEMEN	SCB1/CSWI1.Pos.SBOw.Check	Check	No-Check	
SIEMEN	SCB1/CSWI1.Pos.SBOw.ctlNum	INT8U	6	
SIEMEN	SCB1/CSWI1.Pos.SBOw.ctlVal	BOOLEAN	False	
SIEMEN	SCB1/CSWI1.Pos.SBOw.origin.orCa	Enum	remote-control	
SIEMEN	SCB1/CSWI1.Pos.SBOw.origin.orlde	Octet64	45-53-32-30-30	
SIEMEN	SCB1/CSWI1.Pos.SBOw.T	Timestamp	2019-08-24 05:18	
SIEMEN	SCB1/CSWI1.Pos.SBOw.Test	BOOLEAN	False	
SIEMEN	SCB1/CSWI1.Pos.stSeld	BOOLEAN	False	
SIEMEN	SCB1/CSWI1.Pos.stVal	Dbpos	Off	
SIEMEN	SCB1/CSWI1.Pos.t	Timestamp	2019-08-24 05:15	-

Figure 97 IEC 61850 Southbound Point List Status

Now the control command is issued from the Northbound TMW simulator to change the state of the register to True/On.
Figure 98	DNP3 IP	Northbound	<b>CROB</b>	Control	Command
-----------	---------	------------	-------------	---------	---------

Control Relay Out	tput Block				
lame: Control R	elay Output Block				
Description The remote devic message, but all	ce may support binary points are not require	output contro d to change at	ol operations to m the same time.	ultiple data points	s in the same
Command Optic	ons				
Mode: DirectNo	Ack	▼ Q	ualifier Code: Six	teenBitIndex	
Control Inform	ation				
Point Number:	1	*	Control Code:	LatchOn	•
Pulse On Time:	100	* *	Pulse Off Time:	100	* *
Count:	1	÷			
Feedback Po	11	Delay Bef	ore Sending 100		▲ ▼
Secure Authent	tication				
User					~
	ggressive Mode				
Scheduler					
On Connect	Periodica	lly 00:00:01			
Execute			F	Apply Of	Close

Command LatchOn is executed on Point Number 1 in Figure 98 above. Mode is DirectNoAck. Control Code is LatchOn. Click **Apply** and then click **Execute** to execute the command from the Northbound DTM application.

Binary Output Statuses Pos.Oper.ctVal register value on the Southbound TMW application is changed from **False** to **True**; this is depicted in Figure 99.

Distributed Test Manager Administration v1.4.0.4 (	127.0.0.1)- © Triangle Microworks, Inc. 2019	-				
File Tools Views Windows Help		0				
🕞 😂 🕞 🔺 . 📖 🤫 🕾 🗟 🛠 .						
Workspace 🔹 🕈 🗙	S Workspace	× 😫 IED				
← 🛞 IEC61850-DNP3-01	1 06:57:38.592: 2 06:57:38.592: ### mDNP - 10.10.32.5:20000 - TCP transmit 10 bytes	Drag a column header and drop it here to group by that column				
- 🦢 IED	3 06:59:19.692: 4 06:59:19.692: ### mDNP - 10.10.32.5:20000 - TCP transmit 10 bytes	Path Y Point Type Y Value				
III SIEMENS	5 07:01:00.864: 6 07:01:00.864: ### mDNP - 10.10.32.5:20000 - TCP transmit 10 bytes	SIEMENSCB1/CSWI1.Pos.Oper.ctlNum INT8U 1				
- <u>+</u> ?	7 07:02:42.035:	SIEMENSCB1/CSWI1.Pos.Oper.ctlVal BOOLEAN True				
9 5 A P1	8 07:02:42.035: ### mDNP - 10.10.32.5:20000 - TCP transmit 10 bytes 9 07:04:23.190:	SIEMENSCB1/CSWI1.Pos.Oper.origin.orCat Enum remote-control				
÷ 2618	10 07:04:23.190: ### mDNP - 10.10.32.5:20000 - TCP transmit 10 bytes	SIEMENSCB1/CSWI1.Pos.Oper.origin.orldent Octet64 45-53-32-30-				
SCADA CC	11 07:06:04.351:	SIEMENSCB1/CSWI1.Pos.Oper.T Timestamp 2019-07-02 07				
* 💹 🔒 🤝	13 07:07:04.425:	SIEMENSCB1/CSWI1.Pos.Oper.Test BOOLEAN False				
mDNP	14 07:07:44.425: ### mDNP - 10.10.32.5:20000 - TCP transmit 10 bytes	SIEMENSCB1/CSWI1.Pos.origin.orCat Enum remote-control				
- <u>u</u> <u>a</u> <del>?</del>	10 07:08:08.350: 16 07:08:08.350: <+++ mDNP Build DNP3 Message: Binary Command	SIEMENSCB1/CSWI1.Pos.origin.orldent Octet64 45-53-32-30-3				
mDNP	17 07:08:08.350:	SIEMENSCB1/CSWI1.Pos.q Quality [0000000000				
- Z <sup>∞</sup> <u>-</u> ∻	18 07:08:08.350: IX ODJECT 12(CONTFOL Relay Output Block), Variation 1, qualifier 0X28(16 Bit 19 07:08:08.356:	SIEMENSCB1/CSWI1.Pos.SBO ObjRef				
mDNP	20 07:08:08.350: <+++ mDNP Insert request in queue: Binary Command	SIEMENSCB1/CSWI1.Pos.sboTimeout INT32U 30000				
* ē	21 07:08:08.350: 22 07:08:08:36: < mDNP Anniistion Header Direct Onerate No Ack	SIEMENSCB1/CSWI1.Pos.SBOw.Check Check No-Check				
	23 07:08:08.350: FIR(1) FIN(1) CON(0) UNS(0) SEQ# 12					
Analog Output Block	24 07:08:08.350: cc 06 0c 01 28 01 00 01 00 03 01 64 00 00 06 64	Select View 🔻 Displaying 2712 of 2712 data points				
Control Polay Output R	26 07:08:08:350:					
Control Kelay Output b	27 07:08:08.350: ### mDNP - 10.10.32.5:20000 - TCP transmit 35 bytes	Control Relay Output Block				
Integrity Data Poll - Cla	28 07:08:09.680: IEC61850/Write, Write Goolean:SlemENSCBJCSWILPOS.SBUW.CTIVal Value: Irue 29 07:08:09.680: IEC61850/Write.Write Control OrCat Enumerated:SIEMENSCBI/CSWILPOS.SBOW.origin.orCat Value: A	Names Constrail Polacy Output Block				
• • • •	30 07:08:09.680: IEC61850/Write, Write SBOControlOrIdent:SIEMENSCB1/CSWI1.Pos.SBOw.origin.orIdent Value: 4553	Description				
	31 07:08:09.696: IEC61850/Write, Write SB0ControlCtlNum:SIENENSCB1/CSW1.Pos.SB0w.tlNum Value: 1 32 07:08:09.696: IEC61850/Write, Write SB0ControlT:SIENENSCB1/CSW1.Pos.SB0w.t Value: 07/02/2019_07:11:30.164 33 07:08:09.696: IEC61856/Write, Write SB0ControlTest:STENENSCB1/CSW1.Pos.SB0w.text Value: False	The remote device may support binary output control operations to multiple data points in the same message, but all points are not required to change at the same time.				
	34 07:08:09.696: IEC61850/Write, Write BitString:SIEMENSCB1/CSWI1.Pos.SBOw.Check Value: no-check	Command Options				
	35 07:08:09.961: IEC61850/Write, Write Boolean:SIEMENSCB1/CSM11.Pos.Oper.ctlVal Value: True 36 07:08:09.961: TEC61850/Write Write Control OrCat Enumerated:SIEMENSCB1/CSW11 Dos Oper.origin orCat Value:	Mode: DirectNoAck				
	37 07:08:09.961: IEC61850/Write, Write SBOControlorIdent:SIEMENSCB1/CSWI1.Pos.Oper.origin.orIdent Value: 4553	Control Information				
	38 07:08:09.961: IEC61850/Write, Write Unsigned:SIEMENSCB1/CSW1.Pos.Oper.ctlNum Value: 1 20 07:09:09 061: IEC61850/Write, Write UTC Time:STEMENSCB1/CSW1.Pos.Oper.ctlNum Value: 1	Point Number: 1 Control Code: LatchOn				
	40 07:08:09.961: IEC61850/Write, Write Bolean:SIEMENSCB1/CSMI1.Pos.Oper.Test Value: False	A D L O// T				
	41 07:08:09.961: IEC61850/Write, Write BitString:SIEMENSCB1/CSWI1.Pos.Oper.Check Value: no-check	Pulse Off Time: 100 v Pulse Off Time: 100 v				
		Count: 1				
		Feedback Poll Delay Before Sending 100				
		Secure Authentication				
		User				
Workspace Percentrar	( )	Scheduler				
workspace Resources		On Connect Periodically 00:00:01.000				
Output						
1		Execute Apply OK Close				



# IEC 61850-MMS (Southbound) to T104 (Northbound) Translation Use Case

## Implementation Details

The Cisco IR809/IR1101 router is connected to an actuator or sensor in the Southbound via Ethernet and uses IEC 61850-MMS as the SCADA communication protocol. Virtual RTU software does the Northbound translation to T104 IP since the Control Center software is running the T104 IP SCADA application.

- Southbound IEC 61850-MMS Actuator is simulated using TMW Test Harness application.
- Northbound T104 SCADA Software is simulated using TMW DTM Application.

#### Figure 100 Implementation Details of T104 to IEC 61850 Translation - 1007



## Southbound IEC 61850-MMS TMW Configuration

## **Channel Configuration**

The Southbound IED is simulated using TMW software. In this example, the TMW simulated IEC 61850-MMS IED is connected to GigabitEthernet1 of IR809 or FastEthernet0/0/1 of IR1101.

### Figure 101 IEC 61850-MMS Channel Configuration

IEC 61850 Server Cl	nannel Configuration	_ <b>=</b> ×
Basic Advanced		
Channel Name P SCL File IEC 61850 Serve specified in the S SCL File SIE IED to Load SIEI Access Point P1 Connection Prop	1 rs will be instanced as Edition 1 devices unless the IED's 'originalScIVersion' and 'orig SCL file. MENS-NewBox.iid WENS erties	inalScIRevision' attributes are
Port	102 \$	
GUUSE Adapter	•	GUUSE Loopback Enabled
		OK Cancel

## Figure 102 IEC 61850 Advanced Channel Configuration

61850 Server Channel Configuration		_ = = :
sic Advanced		
A-Z		
Seven Layer Addressing		
Auto Data Changes		
Allow Auto Updates On Specific Attri		
File Services		
Allow Directory Listing	<ul> <li></li> </ul>	
Allow File Delete	<ul> <li></li> </ul>	
Allow File Download	V	
Allow File Upload	v	
File Services Root Directory	C:\ProgramData\Triangle MicroWorks\DTM\Files	
Security		
Certificate Authority Chaining Verfica	1	
Certificate Authority File		D 🖬
Certificate Authority Revocation List F		D 🖬
Cipher	TLSv1:ISSLv2:IaNULL:IeNULL:ICAMELLIA:IEXPORT40:IEXPORT56:@STRENGTH	
Diffie Hellman File Name		D 📋
Directory to Certificate Authority		
IEC 62351 Edition 1		
MMS Common Name		
MMS Private Key file		D 🖬
MMS Private Key PassPhrase		
MMS Public Certifcate File		D 🖬
OpenSSLMethod	TLSV1	*
OpenSSLOption	NOT_USED	*
SecurityMechanism	None	*
TLS Common Name		
TLS Max PDU's before forcing cipher	100	
TLS Max renegotiate wait time	0	
TLS Private Key File		D 🖬
TLS Private Key PassPhrase		
TLS Public Certificate File		D 🗊
TLS Renegotiation (Seconds)	1000	

sic Advanced		
🗏 A-Z		
TLS Private Key PassPhrase		
TLS Public Certificate File		12 🔟
TLS Renegotiation (Seconds)	1000	
Weak-Password		
Configuration		
Channel Name	P1	
ConnectDelay	0	
Enabled	✓	
ForceDisconnected		
IPv6		
Online	×	
RxBufferSize	256	
System Frequency	60	
UseConnectorThread		
Win232Disabled		
Ethernet Adapters		
GOOSE Adapter		*
GOOSE Loopback	Off	Ŧ
Sampled Values Adapter		Ŧ
Sampled Values Loopback		
Basic		
IED Name		
SCL File	SIEMENS-NewBox.iid	D 🖬
Server AP	P1	*
Server IED	SIEMENS	
Server Specific		
Ignore SCL Control Block Setting	s	
Ignore SCL Services		
Connection		
Local Address	0.0.0.0	
Maximum PDU Size	65535	
Server Port	102	

## Figure 103 IEC 61850 Channel Configuration Advanced Continued

# Northbound T104 TMW Configuration

## **Channel Configuration**

The Northbound Ethernet SCADA Control Center is simulated using DTM software. In this example, Port 2404 is used for communication between the Northbound Control Center and the Virtual RTU ES200. See Figure 104:

## Figure 104 Northbound T104 Configuration

Z IEC60870-5-104 Channel Editor	
Channel Advanced	
Channel Name m104	
Behavior O All  O Master  O Monitor  O Peer ( TCP/IP Parameters	🛇 Slave 🔘 Unknown
Mode	
Client     Server	
Local Address 0.0.0.0 - Any Adaptor	•
Remote Address 10.10.70.250	
Port 2,404	
Message Timeouts	Message Buffer Settings
t1 35,000	k 12
t2 10,000	w 8
t3 20,000	
Enable Redundancy	
	OK Cancel

## T104 (Control Center) to IEC 61850-MMS (IED) Register Mapping

The ES200 Virtual RTU software maps and translates different registers in the IEC 61850-aware Southbound device to the T104 protocol-aware Northbound Control Center. The sample register mappings in use by the current version of the ES200 application evaluated in the Connected Utilities Solutions lab are shown in Figure 105:

### Figure 105 T104 to IEC 61850 Point List mapping - 1008

T104 IP (Northbound)	IEC61850-MMS (Southbound)	Type of Register
Single Point Commands	OPER - ctlNum - operVal	Control Registers or Write Registers
Double Point Information	POS -stVal -q -t	Measurement or Input Registers

## Reading IEC 61850 Southbound Data from Northbound T104 Control Center

As the register mapping depicts Double Bit Information in the Northbound T104, the Control Center is mapped to the Double Point register Pos.Oper.st in IEC 61850 Southbound device. Double Point Information in the Control Center should show the corresponding Double Point Binary values set in the IEC 61850 Southbound device.

## Northbound Control Center General Interrogation

See Figure 106:

## Figure 106 Reading Double Point Information

Distributed Test Manager Administration v1.4.0.4 (	(127.0.0.1)- © Triangle Microwork	cs, Inc. 2019									
File Tools Views Windows Help											
🕞 😂 🕞 🙏 🖕 ! 🕅 🧐 🖆 💽 💸 🖕											
Workspace * # ×	🗐 m104					×	😑 Р1				
▲ 🍘 롣 🙆 🖉	C61850-DNP3-02-T104 Drag a column header and drop it here to group by that column			Drag a column header and drop it here to group by that column							
m104	Point Type 🛛 🔻	Value 🛛 🝸	ŧ.Ţ	Name	Ŧ	Quality	Path 🔷 🝸	Point Typ 🏾 🔻	Value T	FC T	
¥ 🔶	[1] Single Point Information	False	1			Valid	SIEMENSCB1/CSWI1.Pos.origin.orldent	Octet64	45-53-32-30-30	ST	T
- 5 🔊 m104	[1] Single Point Information	False	2			Valid	SIEMENSCB1/CSWI1.Pos.q	Quality	[000000000000]	ST	
4	[3] Double Point Information	Intermediate	0	MDPNA #0		Valid	SIEMENSCB1/CSWI1.Pos.SBO	ObjRef		CO	
🗕 🗧 🔜 m104	[3] Double Point Information	On	1	MDPNA #1		Valid	SIEMENSCB1/CSWI1.Pos.sboTimeout	INT32U	30000	CF	
	[3] Double Point Information	Intermediate	2	MDPNA #2		Valid	SIEMENSCB1/CSWI1.Pos.SBOw.Check	Check	No-Check	CO	
I m104	[3] Double Point Information	Intermediate	3			Valid	SIEMENSCB1/CSWI1.Pos.SBOw.ctlNum	INT8U	3	CO	Τ
Double Point C_DC_NA							SIEMENSCB1/CSWI1.Pos.SBOw.ctlVal	BOOLEAN	True	CO	
							SIEMENSCB1/CSWI1.Pos.SBOw.origin.orCa	Enum	remote-control	CO	
🛛 🜔 General Interrogation							SIEMENSCB1/CSWI1.Pos.SBOw.origin.orlde	Octet64	45-53-32-30-30	CO	
0							SIEMENSCB1/CSWI1.Pos.SBOw.T	Timestamp	2019-08-23 13:44	CO	
Single Point C_SC_NA							SIEMENSCB1/CSWI1.Pos.SBOw.Test	BOOLEAN	False	CO	
👝 👝 IED							SIEMENSCB1/CSWI1.Pos.stSeld	BOOLEAN	False	ST	
<b>~</b>							SIEMENSCB1/CSWI1.Pos.stVal	Dbpos	On	ST	
L SIEMENS							SIEMENSCB1/CSWI1.Pos.t	Timestamp	2019-08-23 13:41	ST	T
0 5							SIEMENSCB1/GAPC1.Beh.q	Quality	[000000000000]	ST	T
19 La 19							SIEMENSCB1/GAPC1.Beh.stVal	Enum	on	ST	T
							SIEMENSCB1/GAPC1.Beh.t	Timestamp	2019-08-23 13:30	ST	T
► m SCADA CC							SIEMENSCB1/GAPC1.Health.q	Quality	[000000000000]	ST	
							SIEMENSCB1/GAPC1.Health.stVal	Enum	Ok	ST	
							SIEMENSCB1/GAPC1.Health.t	Timestamp	2019-08-23 13:30	ST	
							SIEMENSCB1/GAPC1.Mod.ctlModel	Enum	status-only	CF	
							SIEMENSCB1/GAPC1.Mod.q	Quality	[0000000000000]	ST	٦,
							SIEMENSCB1/GAPC1.Mod.stVal	Enum	on	ST	0
	4					•					ľ

The Double Point register Pos.Oper.stVal on IED is read by the T104 General Interrogation command and the results are updated in Double Point Information register of T104 in Control Center.

## **Control Command**

For the Control command example, a Single Point Control Command is sent from Control Center using the T104 protocol. The ES200 application translates T104 command to the IEC 61850 command, the southbound IEC 61850 IED Boolean register Pos.Oper.ctVal is updated with the control command, and also internally IEC 61850 updates the Double Point register Pos.Oper.stVal value of IED. This Double Point register Pos.Oper.stVal is read by T104 General Interrogation command and the results are updated in Double Point Information register of T104.

Initial status of Pos.Oper.ctVal and Pos.Oper.stVal registers of IED are shown in Figure 107:



#### Figure 107 IEC 61850 IED Initial Register Status

- The register value of Pos.Oper.ctVal is False
- The register value of Pos.Oper.stVal is Off

Figure 107 captures the Control Command from the Northbound application, which is configured to work in the T104 SCADA protocol. The Southbound application is configured to work in the IEC 61850 SCADA protocol. The intermediate Virtual RTU converts the T104 command into the IEC 61850 command. We are issuing a control command to toggle the value of register from False to True, which is depicted in Figure 108:

#### Figure 108 Single Point Control Command

Single Point C_SC_NA	×
Name: Single Point C_SC_NA	Select Device(s) 💌
Description The Single Point command writes a new data value to the specified point.	
Command Options	
IOA: 1 C Value: O On Off	
Qualifier  Default Short Pulse Long Pulse Persistent	
Control Mode     Select/Execute Select Execute Deactivate	
Scheduler	
On Connect Periodically 00:00:01.000	
Execute Apply OF	Close

Single Point command is executed on IOA address 1 in Figure 108, with Qualified as Default and Control Mode as Select/Execute. Click **Apply** and then click **Execute** to execute the command from the Northbound DTM application.



#### Figure 109 IEC 61850 Double Point Status

- The Double Point register value of Pos.Oper.stVal is On
- The Boolean register value of Pos.Oper.ctVal is True

The Southbound IEC 61850 IED Boolean register Pos.Oper.ctVal is updated in Double Point register Pos.Oper.stVal value of IED. This Double Point register Pos.Oper.stVal is read by T104 General Interrogation command and the results are reflected in the Double Point Information register of T104.

#### Limitations

# Limitations

This section covers the list of open limitations in the system.

The Virtual RTU ES200 database changes based on different protocol translations that need to be done manually by using the Windows-based ES200 desktop application. Then the database is exported to the Cisco IoT Gateway devices. Eximprod is working with the Cisco Fog Director Team to bring in support for editing the ES200 database from the Fog Director.

# References

# **Cisco Documentation**

Cisco IR809: Cisco 809 Industrial Integrated Services Routers Data Sheet at the following URL:

https://www.cisco.com/c/en/us/products/collateral/routers/809-industrial-router/datasheet-c78-734980.html

Cisco IR1101: Cisco IR1101 Industrial Integrated Services Routers Data Sheet at the following URL:

https://www.cisco.com/c/en/us/products/collateral/routers/1101-industrial-integrated-services-router/datasheet-c 78-741709.html

Cisco ASR 1000: Cisco ASR 1000 Series Aggregation Services Routers at the following URL:

https://www.cisco.com/c/en/us/products/routers/asr-1000-series-aggregation-services-routers/index.html

Cisco Fog Director at the following URL:

https://www.cisco.com/c/en\_in/products/cloud-systems-management/fog-director/index.html

Cisco IOx Data Sheet at the following URL:

https://www.cisco.com/c/en/us/products/collateral/cloud-systems-management/iox/datasheet-c78-736767.html

# **Eximprod Documentation**

ES200 Data Sheet (ES200 Supervision, Control and Communication RTU Gateway) at the following URL:

http://www.epg.ro/wp-content/uploads/2017/09/ES200-Datasheet-public.pdf

Eximprod SCADA at the following URL:

http://www.epg.ro/en/scada/

# General Documentation

EuroElectric Power Distribution in Europe Facts & Figures at the following URL:

https://www3.eurelectric.org/media/113155/dso\_report-web\_final-2013-030-0764-01-e.pdf

### Glossary

# Glossary

The following table lists and expands the acronyms and initialisms used in this document.

Term	Expansion
ASR	Cisco Aggregation Services Routers
CROB	Control Relay Output Block
CVD	Cisco Validated Design
DA	Distribution Automation
DMVPN	Dynamic Multipoint Virtual Private Network
DNP	Distributed Network Protocol
DSO	Distribution System Operator
DTM	TMW Distributed Test Manager
FAN	Field Area Network
FLISR	Fault Location Identification and Service Restoration
FND	Field Network Director
HER	Headend Router
IED	Intelligent End Device
loT	Internet of Things
IPv4	Internet Protocol Version 4
LAN	Local Area Network
LTE	Long Term Evolution
LXC	Linus Container
MMS	Manufacturing Message Specification
NAT	Network Address Translation
PaaS	Platform as a service
RBE	Report by Exception
RTU	Remote Terminal Unit
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
ТСР	Transmission Control Protocol
TMW	Triangle MicroWorks