# Connected Utilities Virtual RTU Implementation Guide

October 2019

**Cisco Systems, Inc.** www.cisco.com

THE SPECIFICATIONS AND INFORMATION REGARDING THE PRODUCTS DESCRIBED IN THIS DOCUMENT ARE SUBJECT TO CHANGE WITHOUT NOTICE.  THIS DOCUMENT IS PROVIDED “AS IS.”

ALL STATEMENTS, INFORMATION, AND RECOMMENDATIONS IN THIS DOCUMENT ARE PRESENTED WITHOUT WARRANTY OF ANY KIND, EXPRESS, IMPLIED, OR STATUTORY INCLUDING, WITHOUT LIMITATION, THOSE OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT OR ARISING FROM A COURSE OF DEALING, USAGE, OR TRADE PRACTICE.  IN NO EVENT SHALL Cisco BE LIABLE FOR ANY INDIRECT, SPECIAL, CONSEQUENTIAL, PUNITIVE, EXEMPLARY, OR INCIDENTAL DAMAGES UNDER ANY THEORY OF LIABILITY, INCLUDING WITHOUT LIMITATION, LOST PROFITS OR LOSS OR DAMAGE TO DATA ARISING OUT OF THE USE OF OR INABILITY TO USE THIS DOCUMENT, EVEN IF Cisco HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

All printed copies and duplicate soft copies of this document are considered uncontrolled. See the current online version for the latest version.

Cisco has more than 200 offices worldwide. Addresses, phone numbers, and fax numbers are listed on the Cisco website at www.cisco.com/go/offices.

# Contents

# Connected Utilities Virtual RTU Implementation Guide

This implementation guide includes the following major sections:

## Introduction

This chapter includes the following topics

## 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.

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

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

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

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.

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

| 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 |

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

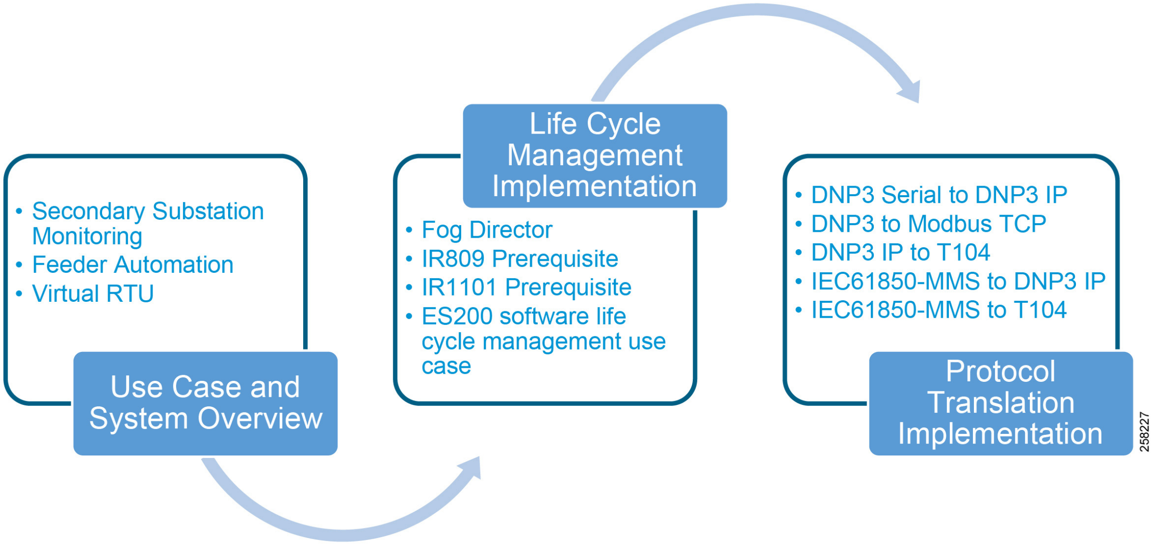
The audience of this guide comprises, but is not limited to, system architects, network/compute/system engineers, field consultants, Cisco Advanced Services specialists, and customers.

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.

## 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

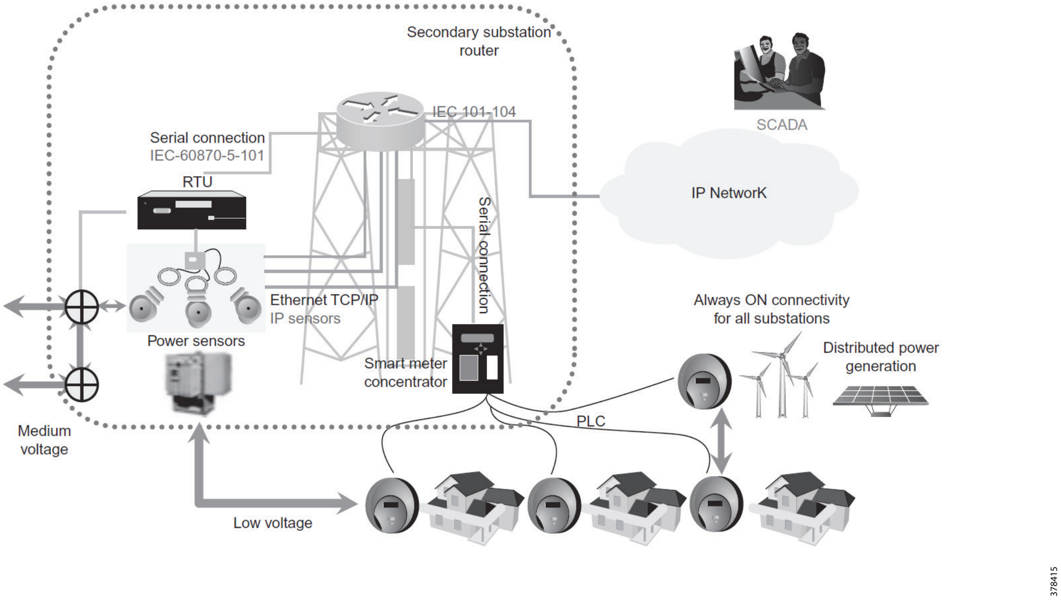
This chapter, which describes secondary substation monitoring, distribution automation, and SCADA Protocol translation use cases and how the use of Virtual RTU will benefit DSOs, includes the following major topics:

## Secondary Substation Monitoring

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.

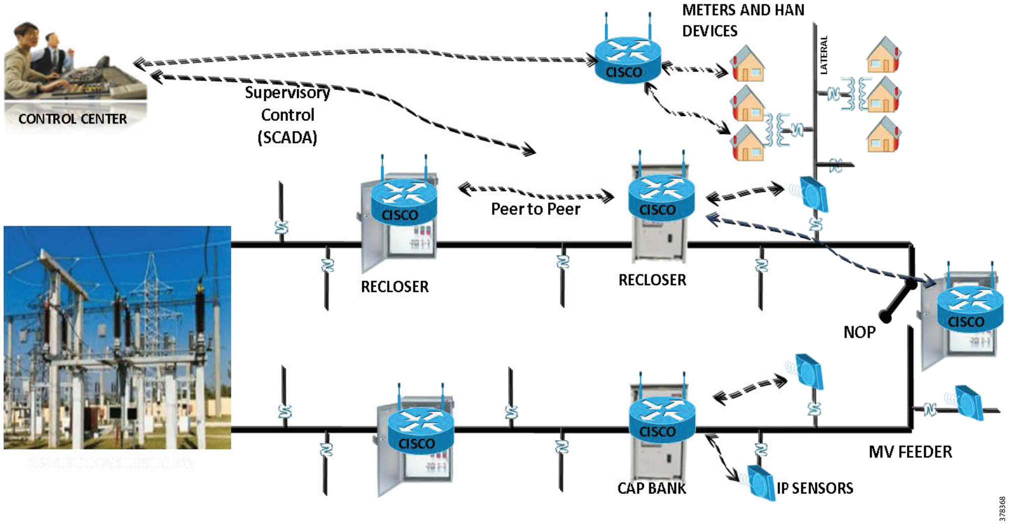
# Distribution (Feeder) Automation

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.

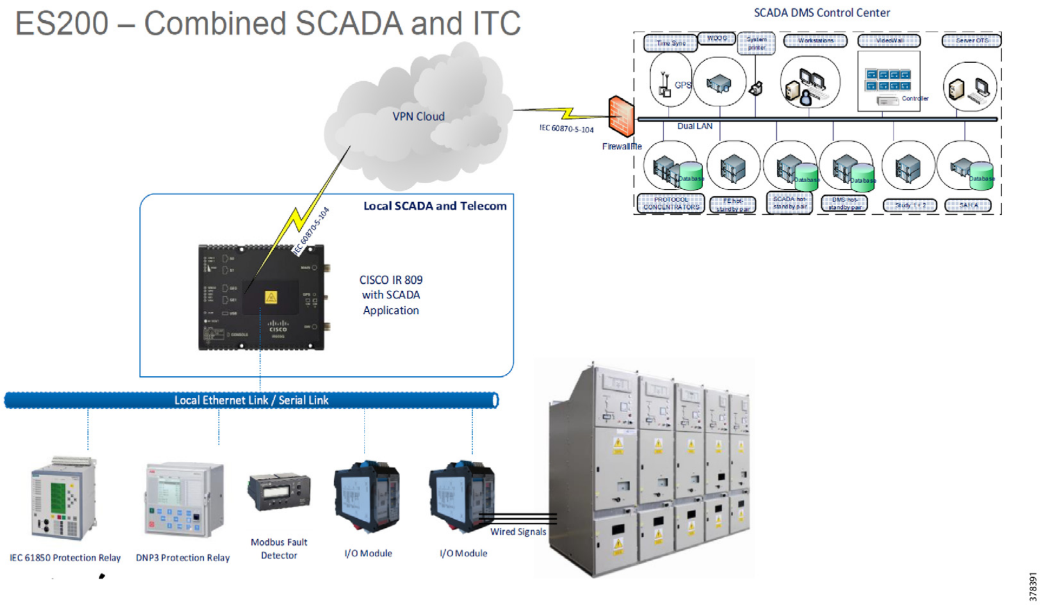
# Virtual RTU and Protocol Translation

## 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.

**Figure 4 Eximprod ES200**



## 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).

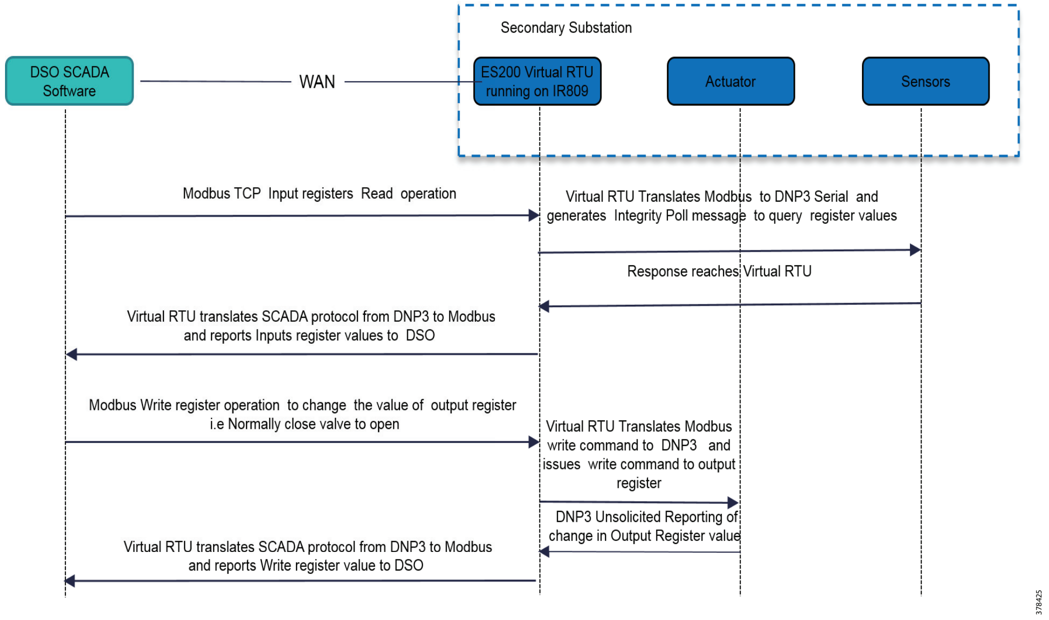

Secondary Substation
DSO SCADA Software
WAN
ES200 Virtual RTU running on IR809
Actuator
Sensors
Modbus TCP Input registers Read operation
Virtual RTU Translates Modbus to DNP3 Serial and generates Integrity Poll message to query register values
Response reaches Virtual RTU
Virtual RTU translates SCADA protocol from DNP3 to Modbus and reports Inputs register values to DSO
Modbus Write register operation to change the value of output register i.e Normally close valve to open
Virtual RTU Translates Modbus write command to DNP3 and issues write command to output register
DNP3 Unsolicited Reporting of change in Output Register value
Virtual RTU translates SCADA protocol from DNP3 to Modbus and reports Write register value to DSO
378425

**Figure 5 SCADA Protocol Translation using Virtual RTU**

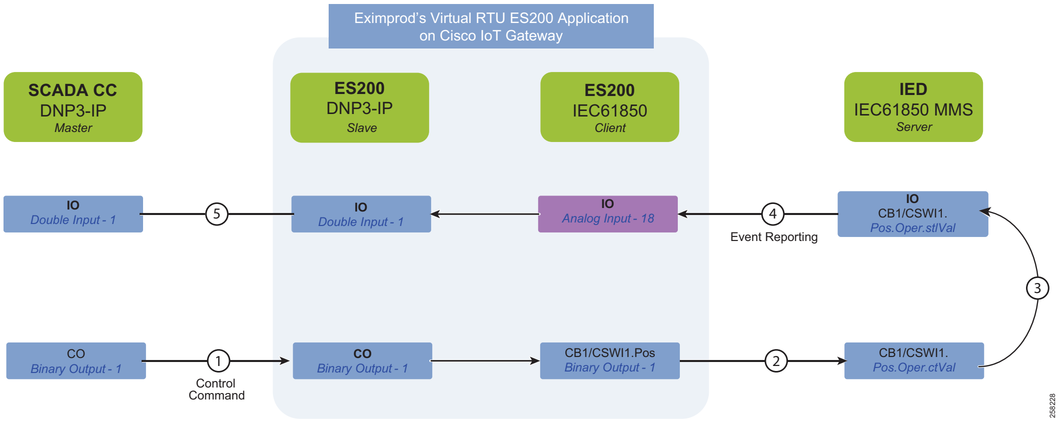
The SCADA protocol translation matrix supported by Virtual RTU is explained in Introduction, page 1. The various SCADA protocol translation implementations are explained in SCADA Protocol Translation Use Case using Virtual RTU, page 30.

**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.

**Figure 6 IEC 61850 SCADA Protocol of IEC 61850 MMS**



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.

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

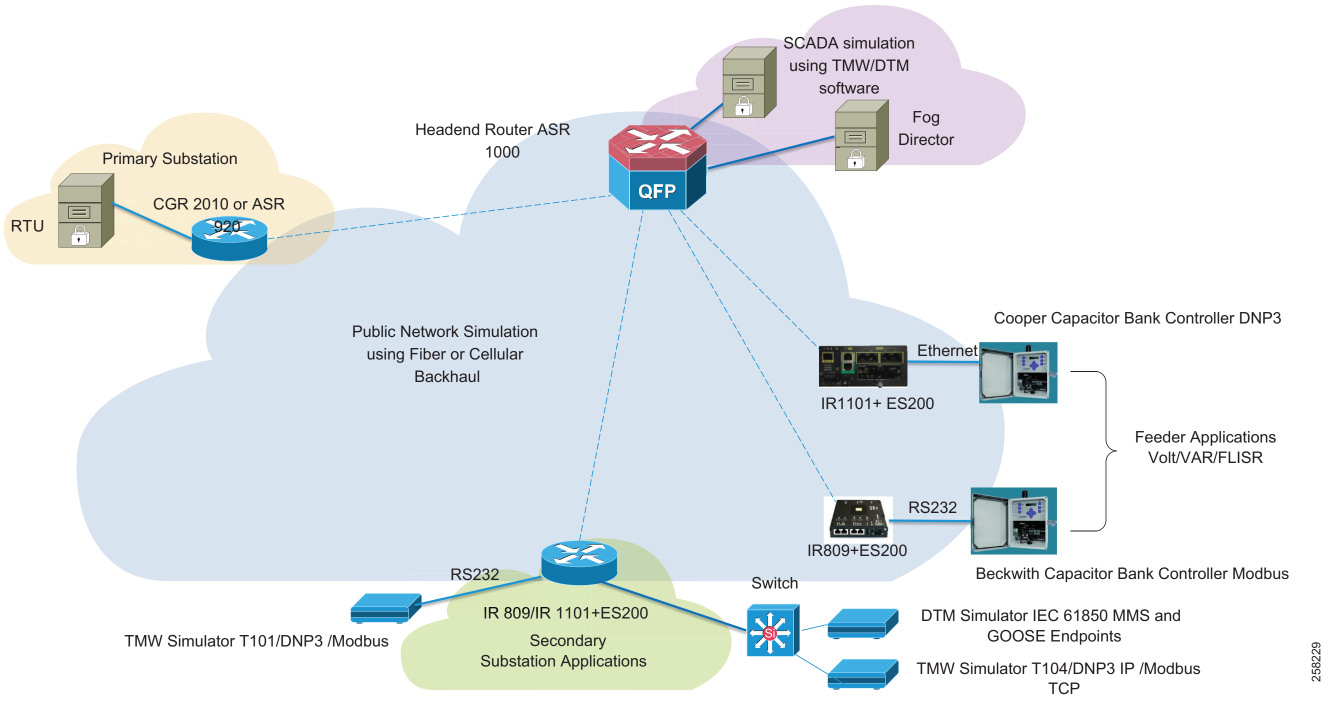
The solution is comprised of the Utilities Distributed System Operator Control Center block (the green cloud in the solution topology in Figure 7), the Wide Area Network (WAN) block, and the Secondary Substation block.

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

**Table 3 Hardware and Software Matrix**

| Device | Software version |
|---|---|
| Cisco IR809 | Refer to the following URL:<br>- https://software.cisco.com/download/home/286287094/type/280805680/release/15.8.3M2a |
| Cisco IR1101 | Refer to the following URL:<br>- 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.<br>- 1.9.0 is the latest available version in CCO, released during the documentation phase. |
| Eximprod ES200 | *Docker container*<br>inovium/es200 tag: 2.1<br>*PaaS application*<br>ir1101_es200_3.8.tar<br>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 |

**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

### 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:

```
DEMO1-89-250#show platform guest-os
Guest OS status:
Installation: Cisco-GOS,version-1.3.2.3
State: RUNNING

DEMO1-89-250#show iox host list
Host Name            IPV4 Address     IPV6 Address                                IOx Client
Version
-------------------------------------------------------------------------------------------------
DEMO1-89-250-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 Current         Type           Suite Next reboot
--------------------------------------------------------------------------------

Technology Package License Information for Module:'ir800'

------------------------------------------------------------------------
Technology    Technology-package                   Technology-package
              Current              Type            Next reboot
------------------------------------------------------------------------
ipbase        ipbasek9             Permanent       ipbasek9
security      securityk9           Permanent       securityk9
data          datak9               Permanent       datak9
```

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
```

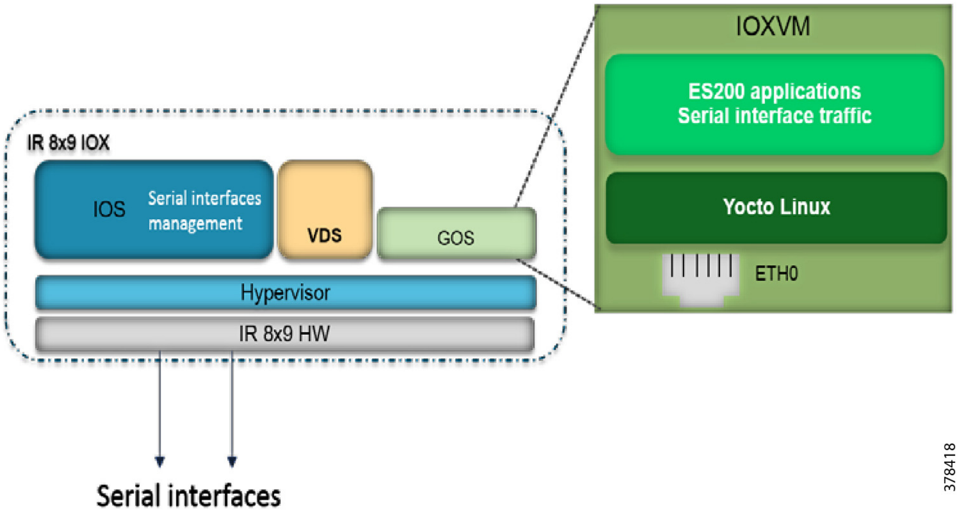
**Note:** Async0 and Async1 reserve line 1/5 and 1/6, respectively, to relay serial data to the corresponding GuestOS /dev/ttyS1 and /dev/ttyS2.

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
```

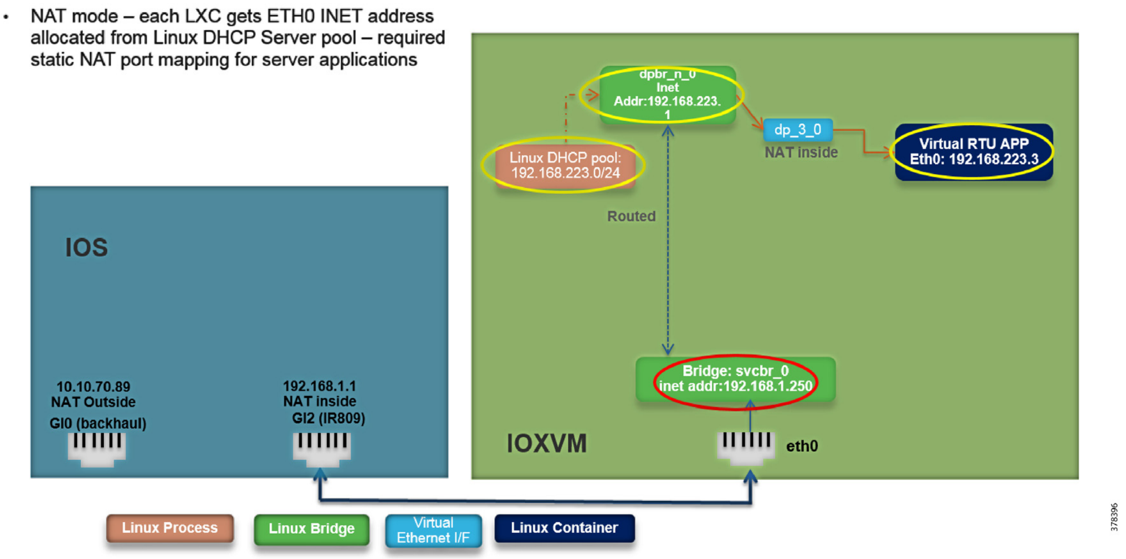
In this example, 192.168.1.250 is the Guest OS IP address. We are doing Static NAT to convert into a public routable IP address. Fog Director uses this public IP address to identify the device.

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**



- NAT mode – each LXC gets ETH0 INET address allocated from Linux DHCP Server pool – required static NAT port mapping for server applications

**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

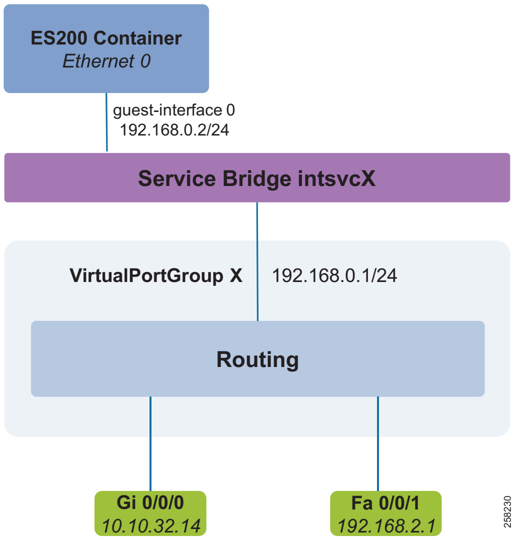
## IR1101 Virtual Port Group Mapping for IOx

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- FCWxxxxxxxxx # configure terminal
IR1101- FCWxxxxxxxxx (config) #
```

3. Delete all entries in the bootable image list:

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

4. Configure boot system variable:

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

5. Save the configuration:

```
IR1101- FCWxxxxxxxxx # write memory
```

6. Reload the device:

```
IR1101- FCWxxxxxxxxx # reload
```

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

```
IR1101-FCWxxxxxxxxx#sh iox-service detail

IOx Infrastructure Summary:
---------------------------
IOx service (CAF)     : Running
IOx service (HA)      : Not Supported
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-FCWxxxxxxxx#show license udi
UDI: PID:IR1101-K9,SN:FCWxxxxxxxx
```

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
!
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=osscdc000283

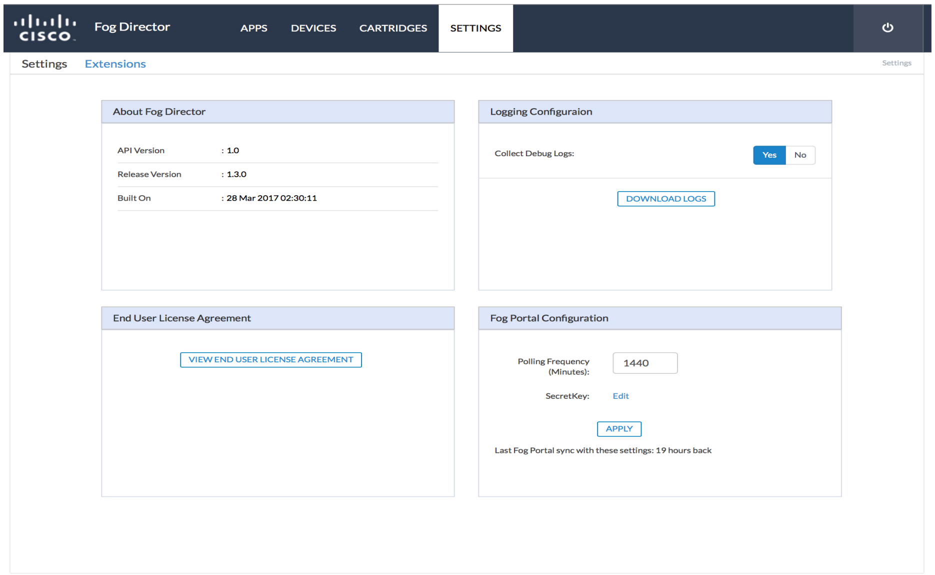
## How to Install Cisco Fog Director

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**



About Fog Director

API Version : 1.0

Release Version : 1.3.0

Built On : 28 Mar 2017 02:30:11

Logging Configuraion

Collect Debug Logs: [✓ Yes] No

Fog Portal Configuration

Polling Frequency (Minutes): 1440

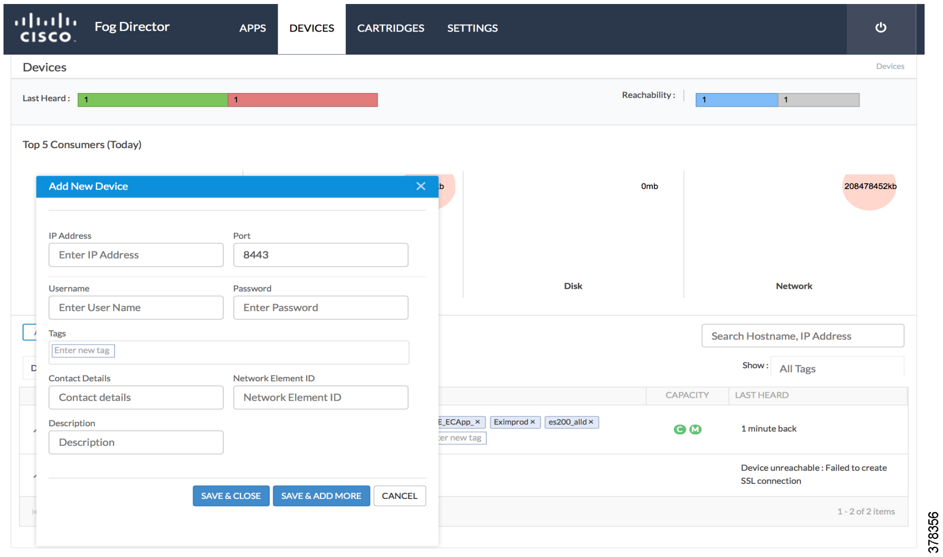
SecretKey: Edit

Last Fog Portal sync with these settings: 19 hours back

## Adding Cisco IR809 Secondary Substation Router into Fog Director

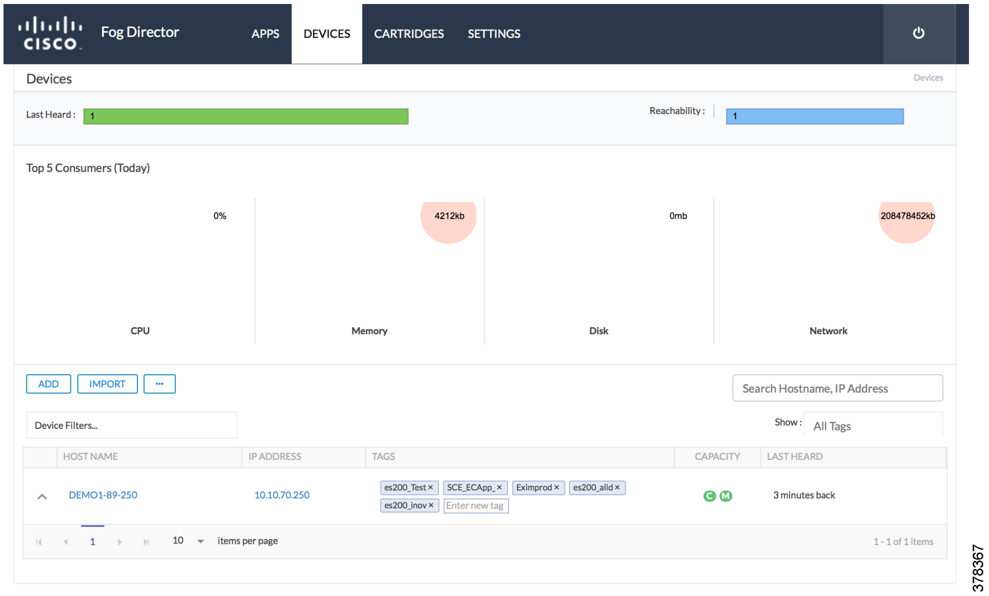
1. From Devices, click **Add**, as shown in Figure 12, and then enter the relevant details for devices such as IP address and port:

### Figure 12 Adding Cisco IR809 in Fog Director



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

### Figure 13 Device Status



| | HOST NAME | IP ADDRESS | TAGS | CAPACITY | LAST HEARD |
|---|---|---|---|---|---|
| ^ | DEMO1-89-250 | 10.10.70.250 | es200_Test × SCE_ECApp_ × Eximprod × es200_alld × es200_inov × Enter new tag | C M | 3 minutes back |

## 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.

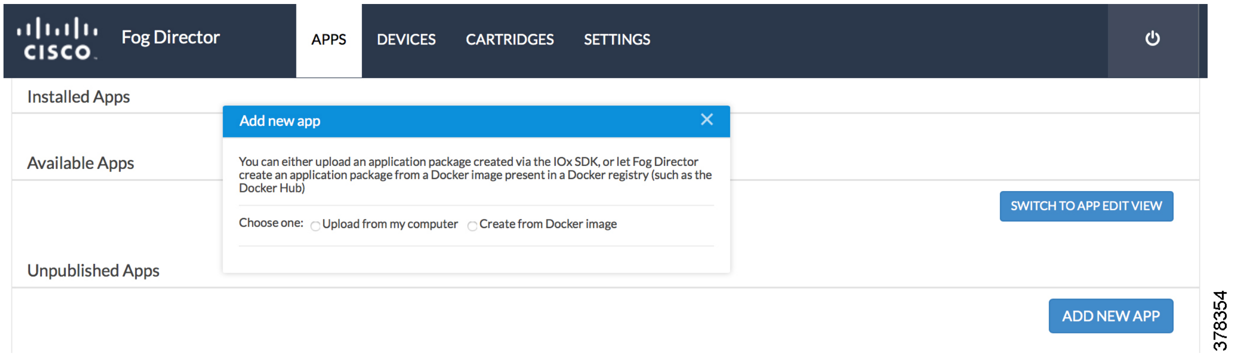
Edit necessary network ports. For example, specify the Northbound ports needed by the Fog Director and device parameters (such as serial interface parameters). Port 1731 will be used by the Virtual RTU. Port 2401 is be used for Northbound communication from the Virtual RTU to Control Center communication.

```
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:

**Figure 14 Add New App**



Add new app

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 ○ Create from Docker image

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

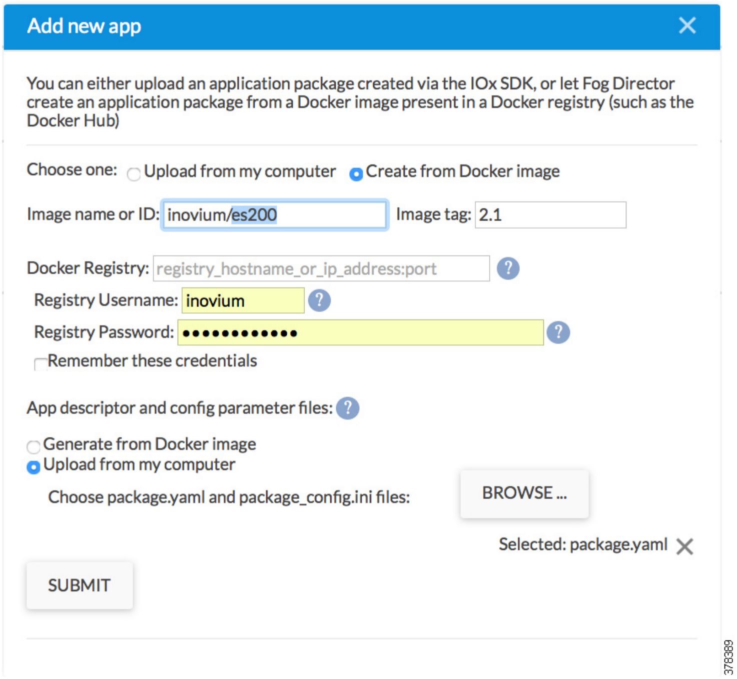
**Note:** For applications other than Docker type, click the **Upload from my computer** checkbox from Figure 14 and jump to Publishing a Newly Added Application, page 21. For the purpose of this document:

- 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 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 ● Create from Docker image

Image name or ID: inovium/es200 Image tag: 2.1

Docker Registry: registry_hostname_or_ip_address:port

Registry Username: inovium

Registry Password: ●●●●●●●●●●●●

□ Remember these credentials

App descriptor and config parameter files:

○ Generate from Docker image
● Upload from my computer

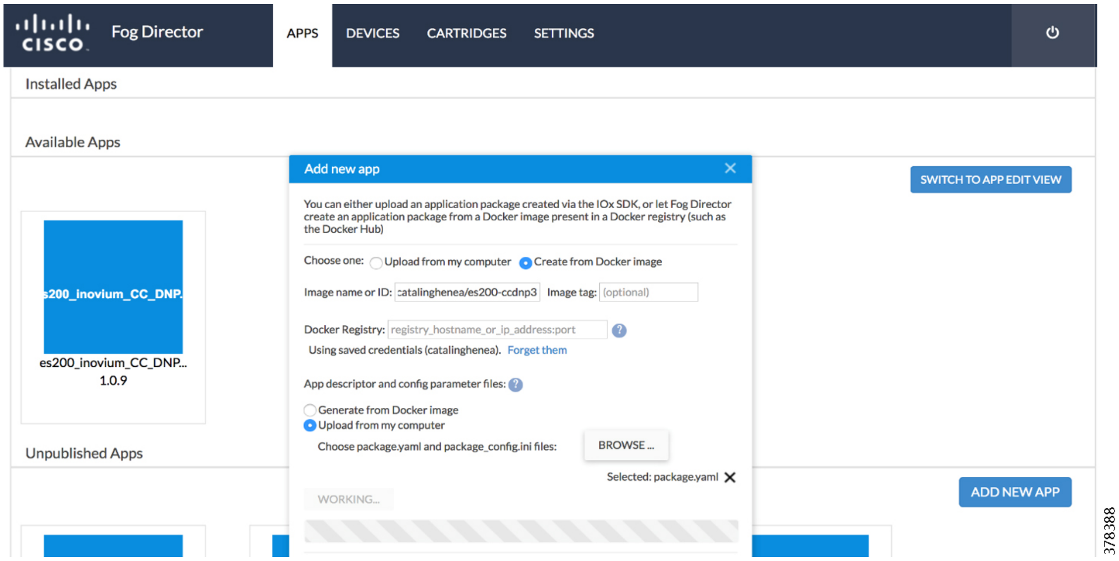
Choose package.yaml and package_config.ini files:

Selected: package.yaml

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*).

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

**Figure 16 Docker Image Details**



Add new app

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 ● Create from Docker image

Image name or ID: :atalinghenea/es200-ccdnp3 Image tag: (optional)

Docker Registry: registry_hostname_or_ip_address:port

Using saved credentials (catalinghenea). Forget them

App descriptor and config parameter files:

○ Generate from Docker image

● Upload from my computer

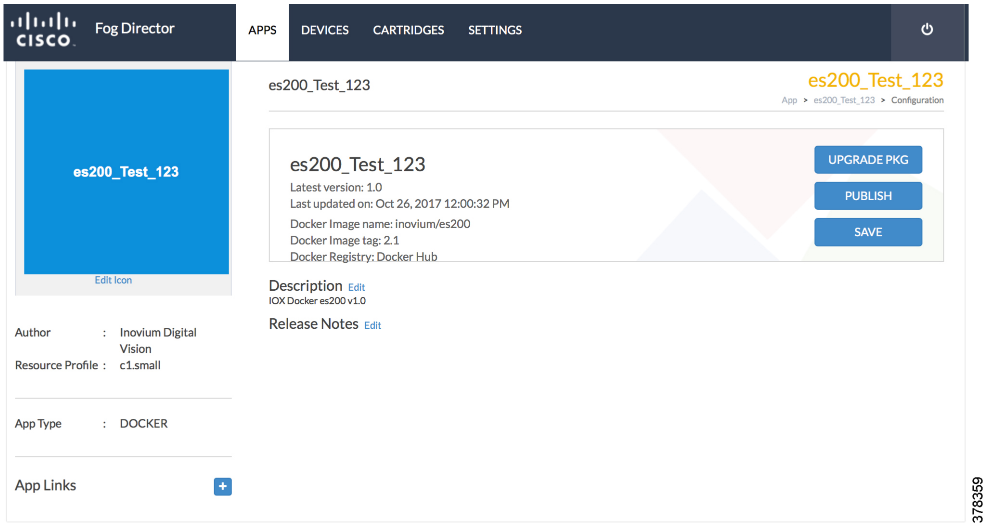
Choose package.yaml and package_config.ini files:

Selected: package.yaml

## Publishing a Newly Added Application

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

**Figure 17 App Publishing**



es200_Test_123

es200_Test_123

Latest version: 1.0

Last updated on: Oct 26, 2017 12:00:32 PM

Docker Image name: inovium/es200

Docker Image tag: 2.1

Docker Registry: Docker Hub

Description

IOX Docker es200 v1.0

Release Notes

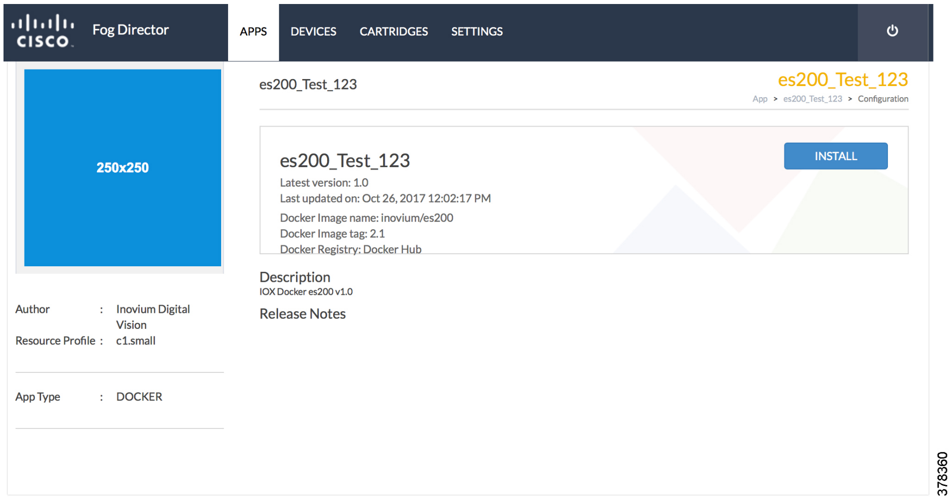
Author : Inovium Digital Vision

Resource Profile : c1.small

App Type : DOCKER

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

### Figure 18 App Ready to Install



es200_Test_123

es200_Test_123

App > es200_Test_123 > Configuration

es200_Test_123

Latest version: 1.0

Last updated on: Oct 26, 2017 12:02:17 PM

Docker Image name: inovium/es200

Docker Image tag: 2.1

Docker Registry: Docker Hub

Description

IOX Docker es200 v1.0

Release Notes

Author : Inovium Digital Vision

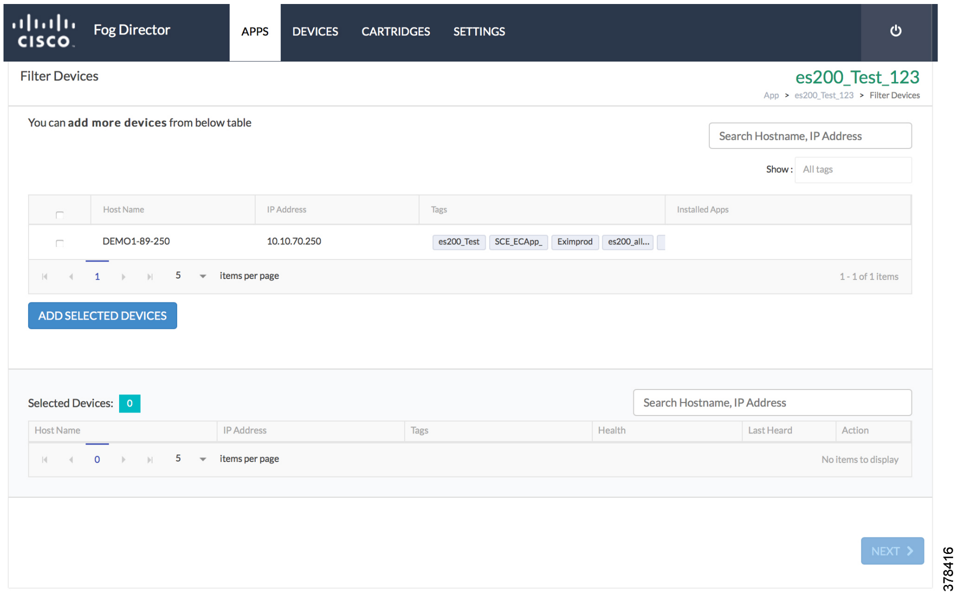
Resource Profile : c1.small

App Type : DOCKER

## 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:

### Figure 19 Select Device



Filter Devices

es200_Test_123

App > es200_Test_123 > Filter Devices

You can **add more devices** from below table

Search Hostname, IP Address

Show : All tags

| ☐ | Host Name | IP Address | Tags | Installed Apps |
|---|---|---|---|---|
| ☐ | DEMO1-89-250 | 10.10.70.250 | es200_Test SCE_ECApp_ Eximprod es200_all... | |

1 5 items per page 1 - 1 of 1 items

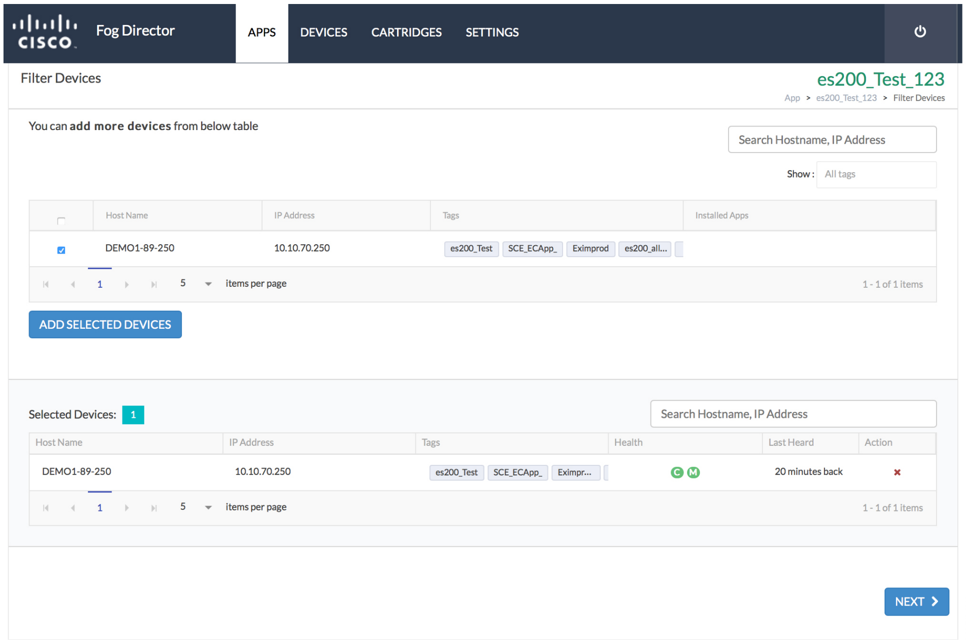
Selected Devices: 0

Search Hostname, IP Address

| Host Name | IP Address | Tags | Health | Last Heard | Action |
|---|---|---|---|---|---|

0 5 items per page No items to display

## Figure 20 Add Selected Devices



Fog Director
APPS
DEVICES
CARTRIDGES
SETTINGS
App > es200_Test_123 > Filter Devices
Search Hostname, IP Address
Show : All tags
ADD SELECTED DEVICES
Search Hostname, IP Address
NEXT
378355

Filter Devices

es200_Test_123

You can **add more devices** from below table

| ☐ | Host Name | IP Address | Tags | Installed Apps |
|---|---|---|---|---|
| ☑ | DEMO1-89-250 | 10.10.70.250 | es200_Test SCE_ECApp_ Eximprod es200_all... | |

1 5 items per page 1 - 1 of 1 items

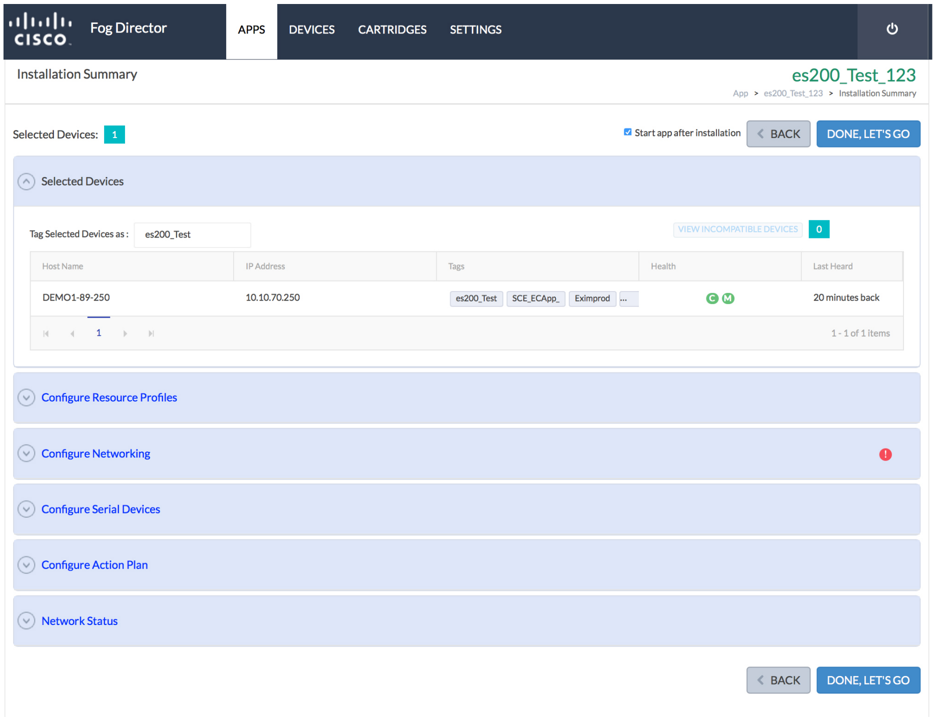
Selected Devices: 1

| Host Name | IP Address | Tags | Health | Last Heard | Action |
|---|---|---|---|---|---|
| DEMO1-89-250 | 10.10.70.250 | es200_Test SCE_ECApp_ Eximpr... | C M | 20 minutes back | ✕ |

1 5 items per page 1 - 1 of 1 items

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

## Figure 21 Resource Profiles



Installation Summary

es200_Test_123

Selected Devices: 1

☑ Start app after installation

Selected Devices

Tag Selected Devices as : es200_Test

| Host Name | IP Address | Tags | Health | Last Heard |
|---|---|---|---|---|
| DEMO1-89-250 | 10.10.70.250 | es200_Test SCE_ECApp_ Eximprod ... | C M | 20 minutes back |

1 1 - 1 of 1 items

Configure Resource Profiles

Configure Networking

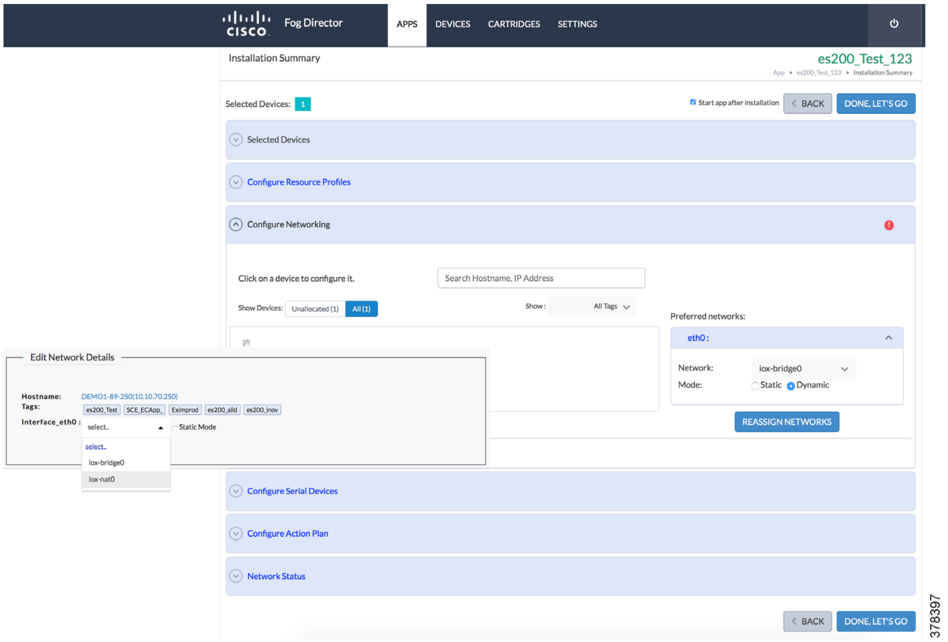
Configure Serial Devices

Configure Action Plan

Network Status

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

### Figure 22 Networking



Installation Summary

es200_Test_123

Selected Devices: 1

☑ Start app after installation

Click on a device to configure it.

Show Devices: Unallocated (1) All (1)

Show: All Tags

Preferred networks:

eth0 :

Network: iox-bridge0

Mode: ○ Static ● Dynamic

Edit Network Details

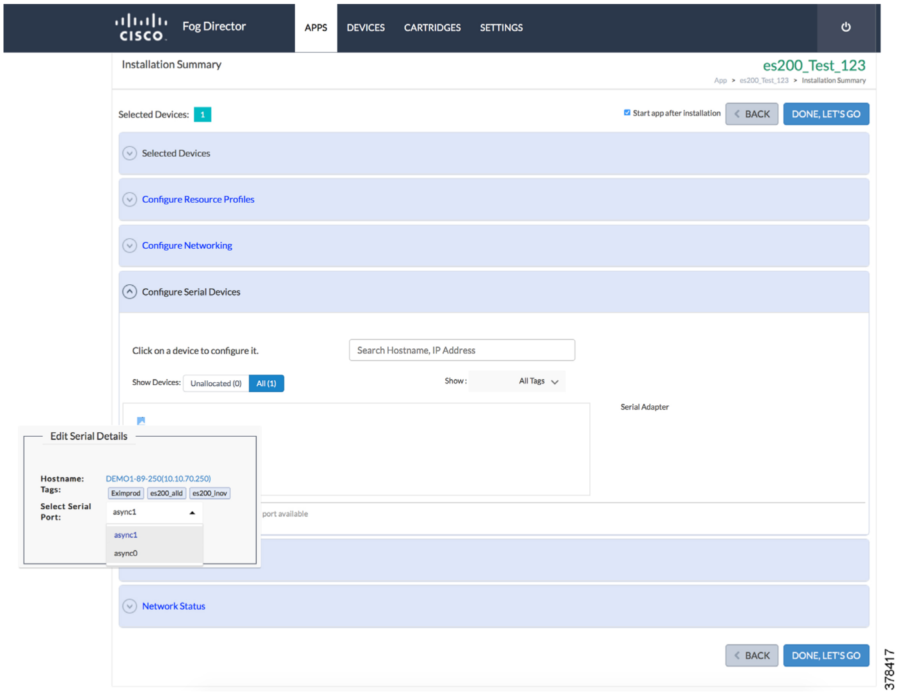
Hostname: DEMO1-89-250(10.10.70.250)

Tags: es200_Test SCE_ECApp_ Eximprod es200_alld es200_inov

Interface_eth0 : select.. □ Static Mode

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.

### Figure 23 Serial Device Details



Installation Summary

es200_Test_123

Selected Devices: 1

☑ Start app after installation

Click on a device to configure it.

Show Devices: Unallocated (0) All (1)

Show: All Tags

Serial Adapter

Edit Serial Details

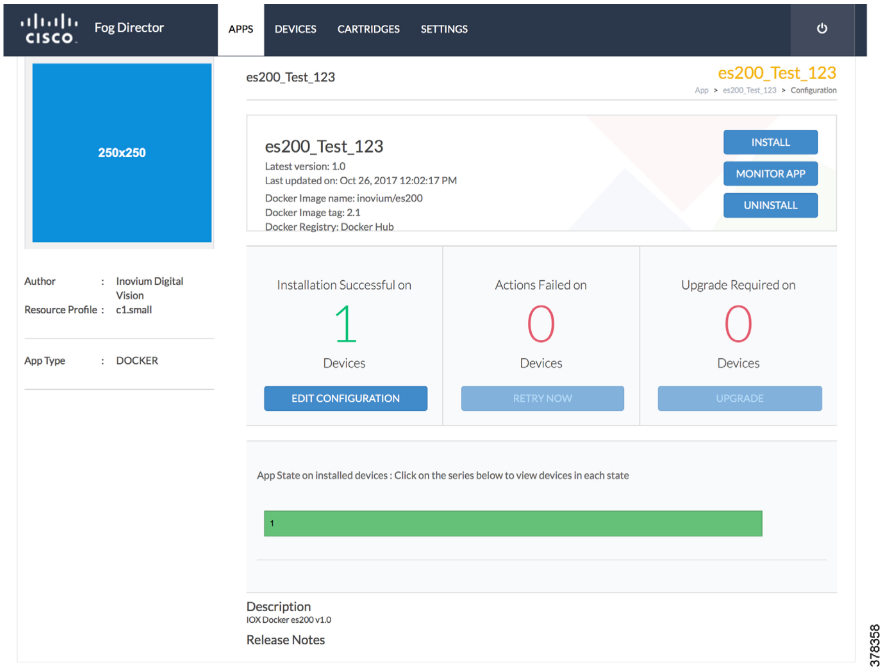
Hostname: DEMO1-89-250(10.10.70.250)

Tags: Eximprod es200_alld es200_inov

Select Serial Port: async1

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:

### Figure 24 App Installation Success



es200_Test_123
Latest version: 1.0
Last updated on: Oct 26, 2017 12:02:17 PM
Docker Image name: inovium/es200
Docker Image tag: 2.1
Docker Registry: Docker Hub

Author : Inovium Digital Vision
Resource Profile : c1.small

App Type : DOCKER

Installation Successful on 1 Devices

Actions Failed on 0 Devices

Upgrade Required on 0 Devices

App State on installed devices : Click on the series below to view devices in each state

Description
IOX Docker es200 v1.0

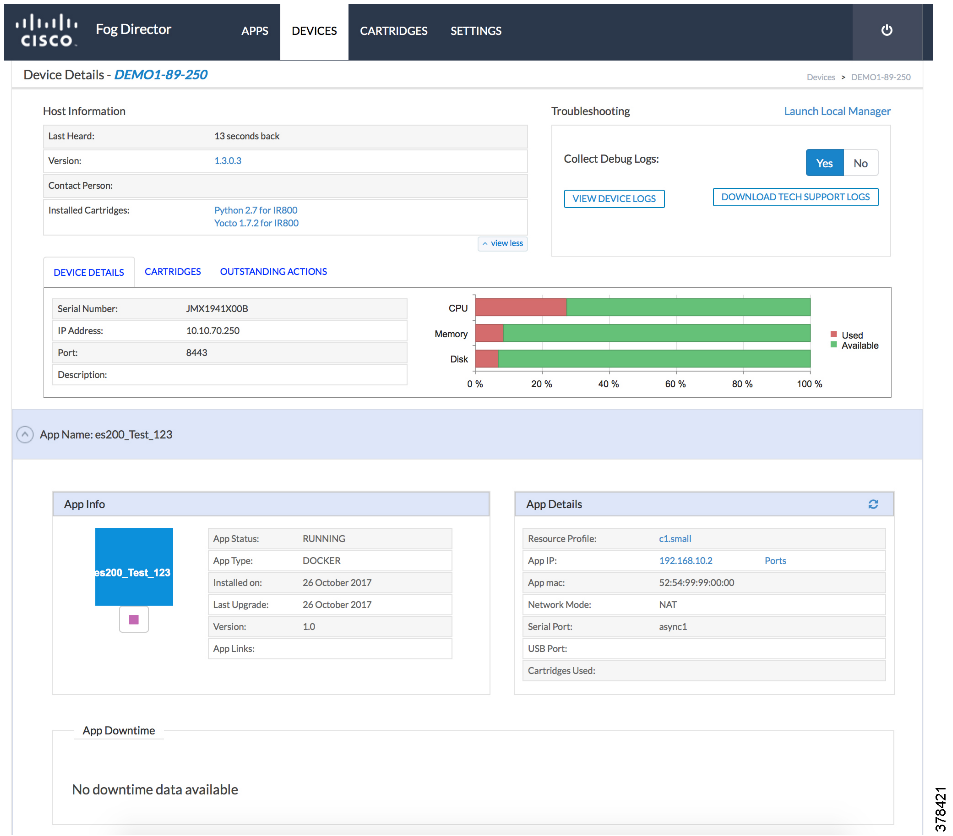
Release Notes

# 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:

### Figure 25 Stopping App



Device Details - *DEMO1-89-250*

Host Information

| | |
|---|---|
| Last Heard: | 13 seconds back |
| Version: | 1.3.0.3 |
| Contact Person: | |
| Installed Cartridges: | Python 2.7 for IR800<br>Yocto 1.7.2 for IR800 |

Troubleshooting

Collect Debug Logs: [✓ Yes] No

| | |
|---|---|
| Serial Number: | JMX1941X00B |
| IP Address: | 10.10.70.250 |
| Port: | 8443 |
| Description: | |

App Name: es200_Test_123

App Info

| | |
|---|---|
| App Status: | RUNNING |
| App Type: | DOCKER |
| Installed on: | 26 October 2017 |
| Last Upgrade: | 26 October 2017 |
| Version: | 1.0 |
| App Links: | |

App Details

| | | |
|---|---|---|
| Resource Profile: | c1.small | |
| App IP: | 192.168.10.2 | Ports |
| App mac: | 52:54:99:99:00:00 | |
| Network Mode: | NAT | |
| Serial Port: | async1 | |
| USB Port: | | |
| Cartridges Used: | | |

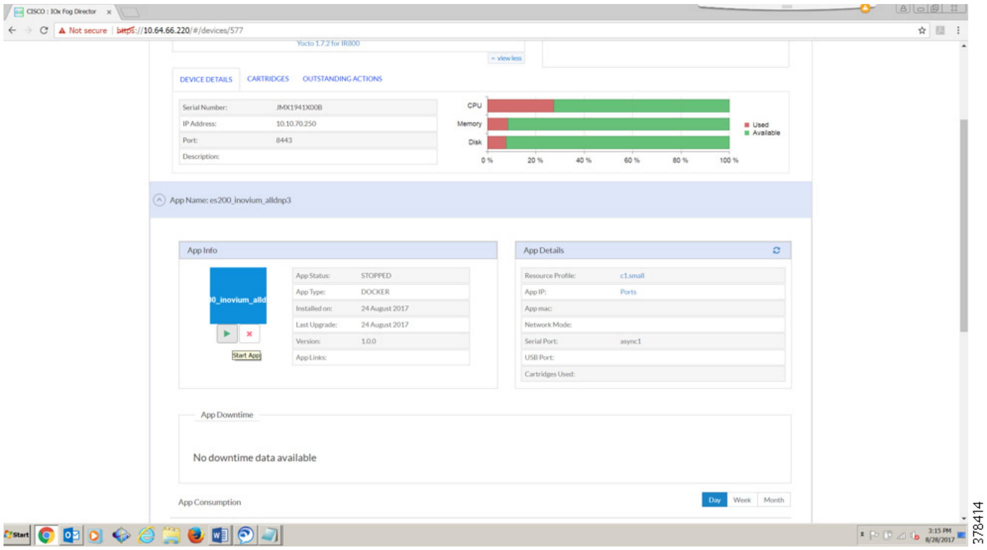
App Downtime

No downtime data available

## 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:

**Figure 26 Restarting App**



Serial Number: JMX1941X00B
IP Address: 10.10.70.250
Port: 8443
Description:

App Name: es200_inovium_alldnp3

App Status: STOPPED
App Type: DOCKER
Installed on: 24 August 2017
Last Upgrade: 24 August 2017
Version: 1.0.0
App Links:

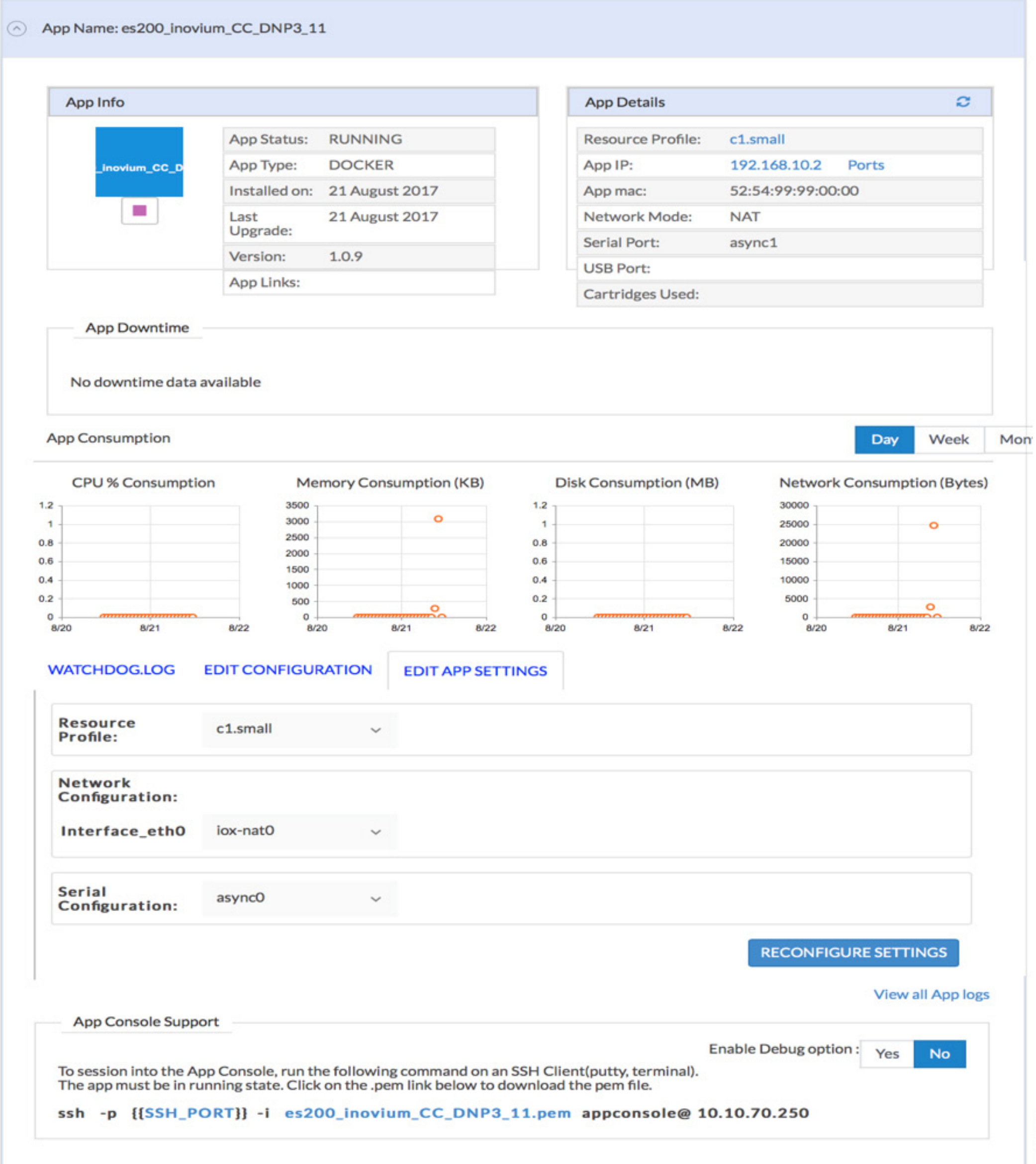
Resource Profile: c1.small
App IP: Ports
App mac:
Network Mode:
Serial Port: async1
USB Port:
Cartridges Used:

No downtime data available

## 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 Name: es200_inovium_CC_DNP3_11

App Info

_inovium_CC_D

| | |
|---|---|
| App Status: | RUNNING |
| App Type: | DOCKER |
| Installed on: | 21 August 2017 |
| Last Upgrade: | 21 August 2017 |
| Version: | 1.0.9 |
| App Links: | |

App Details

| | |
|---|---|
| Resource Profile: | c1.small |
| App IP: | 192.168.10.2 Ports |
| App mac: | 52:54:99:99:00:00 |
| Network Mode: | NAT |
| Serial Port: | async1 |
| USB Port: | |
| Cartridges Used: | |

App Downtime

No downtime data available

App Consumption

Resource Profile: c1.small

Network Configuration:

Interface_eth0 iox-nat0

Serial Configuration: async0

App Console Support

Enable Debug option : Yes **No**

To session into the App Console, run the following command on an SSH Client(putty, terminal).
The app must be in running state. Click on the .pem link below to download the pem file.

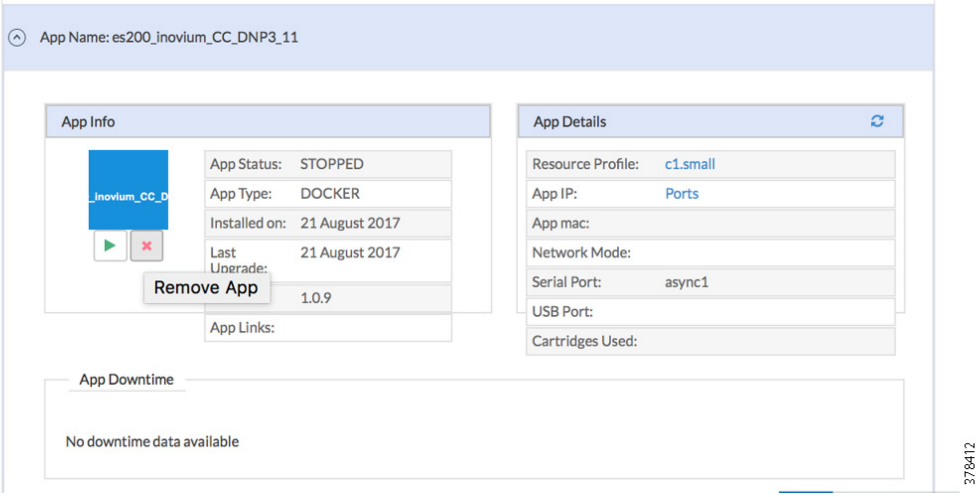
```
ssh -p {{SSH_PORT}} -i es200_inovium_CC_DNP3_11.pem appconsole@ 10.10.70.250
```

378390

## 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 Name: es200_inovium_CC_DNP3_11

App Info

App Status: STOPPED
App Type: DOCKER
Installed on: 21 August 2017
Last Upgrade: 21 August 2017
1.0.9
App Links:

App Details

Resource Profile: c1.small
App IP: Ports
App mac:
Network Mode:
Serial Port: async1
USB Port:
Cartridges Used:

App Downtime

No downtime data available

# 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_IR1101config_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/scada1.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

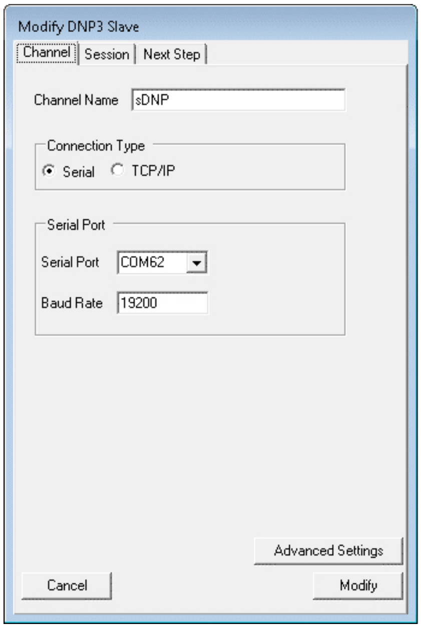
The Cisco IR809 router is connected to an actuator or sensor in the Southbound via Ethernet and uses DNP3 as the SCADA communication protocol. Virtual RTU software does the Northbound translation to DNP3 IP since the Control Center software is running the DNP3 IP SCADA application. The Southbound DNP3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

**Figure 29 DNP3 Channel Configuration**



Channel Name sDNP

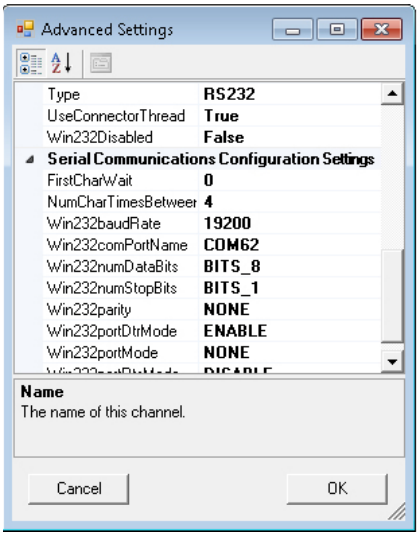
Connection Type
● Serial ○ TCP/IP

Serial Port
Serial Port COM62
Baud Rate 19200

```
DEMO1-89-250#show line
   Tty Line Typ     Tx/Rx    A Modem  Roty AccO AccI  Uses  Noise Overruns  Int
      0    0 CTY              -    -      -    -    -     0      0     0/0     -
*     1    1 TTY  19200/19200 -    -      -    -    -     0      0     0/0     -
*   1/5   71 TTY  19200/19200 -    -      -    -    -     0      0     0/0     -
```

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 Advance Channel Configuration**



Advanced Settings

| | |
|---|---|
| Type | RS232 |
| UseConnectorThread | True |
| Win232Disabled | False |
| **Serial Communications Configuration Settings** | |
| FirstCharWait | 0 |
| NumCharTimesBetweer | 4 |
| Win232baudRate | 19200 |
| Win232comPortName | COM62 |
| Win232numDataBits | BITS_8 |
| Win232numStopBits | BITS_1 |
| Win232parity | NONE |
| Win232portDtrMode | ENABLE |
| Win232portMode | NONE |
| Win232portRtsMode | DISABLE |

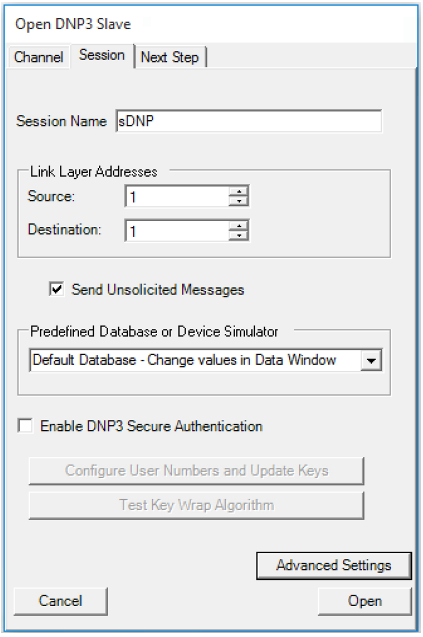
**Name**
The name of this channel.

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

Session Name: sDNP

Link Layer Addresses
Source: 1
Destination: 1

☑ Send Unsolicited Messages

Predefined Database or Device Simulator: Default Database - Change values in Data Window

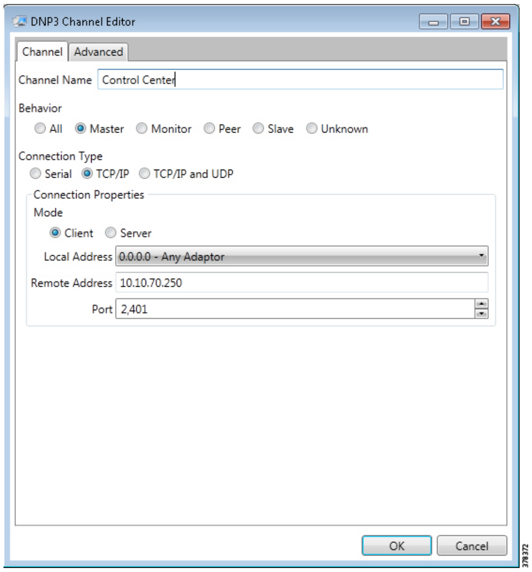
☐ Enable DNP3 Secure Authentication

## 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 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

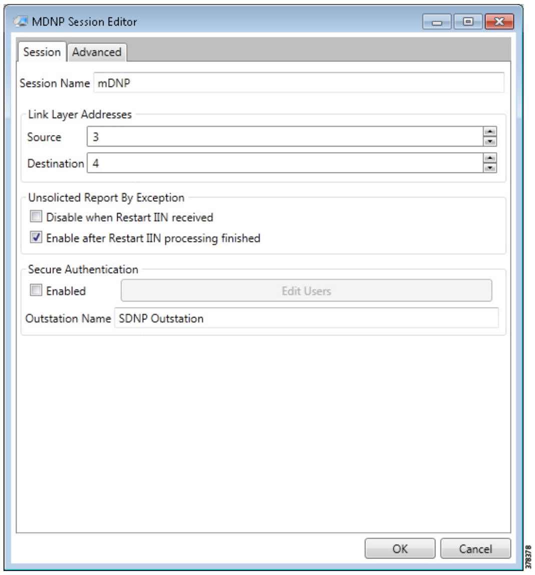
Remote Address: 10.10.70.250

Port: 2,401

### 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**



MDNP Session Editor

Session Name: mDNP

Link Layer Addresses

Source: 3

Destination: 4

Unsolicted Report By Exception

□ Disable when Restart IIN received

☑ Enable after Restart IIN processing finished

Secure Authentication

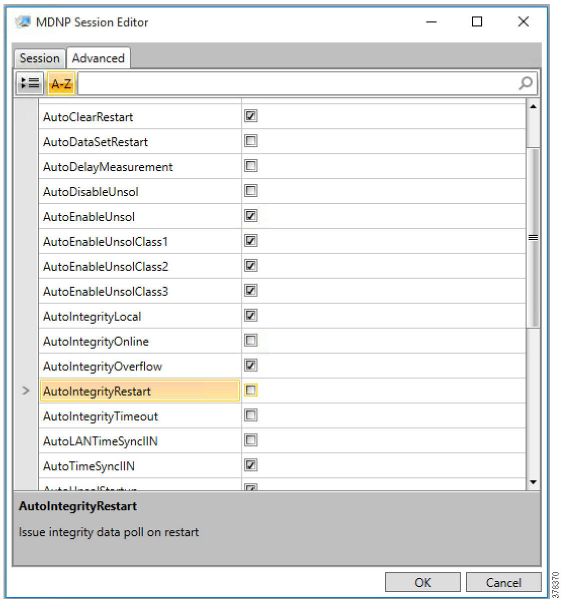
□ Enabled

Outstation Name: SDNP Outstation

## DNP3 IP Advanced Settings

AutoTimeSyncIIN 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:

**Figure 34 DNP3 Advance IP Session Configuration**



MDNP Session Editor

Session | Advanced

| | |
|---|---|
| AutoClearRestart | ☑ |
| AutoDataSetRestart | □ |
| AutoDelayMeasurement | □ |
| AutoDisableUnsol | □ |
| AutoEnableUnsol | ☑ |
| AutoEnableUnsolClass1 | ☑ |
| AutoEnableUnsolClass2 | ☑ |
| AutoEnableUnsolClass3 | ☑ |
| AutoIntegrityLocal | ☑ |
| AutoIntegrityOnline | □ |
| AutoIntegrityOverflow | ☑ |
| AutoIntegrityRestart | □ |
| AutoIntegrityTimeout | □ |
| AutoLANTimeSyncIIN | □ |
| AutoTimeSyncIIN | ☑ |

**AutoIntegrityRestart**

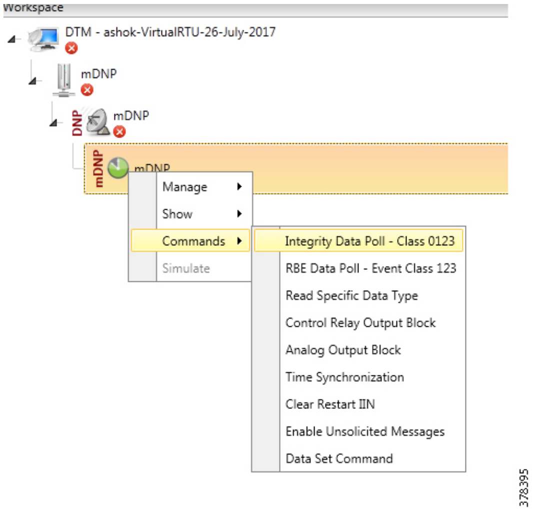
Issue integrity data poll on restart

## Integrity Poll Use Case

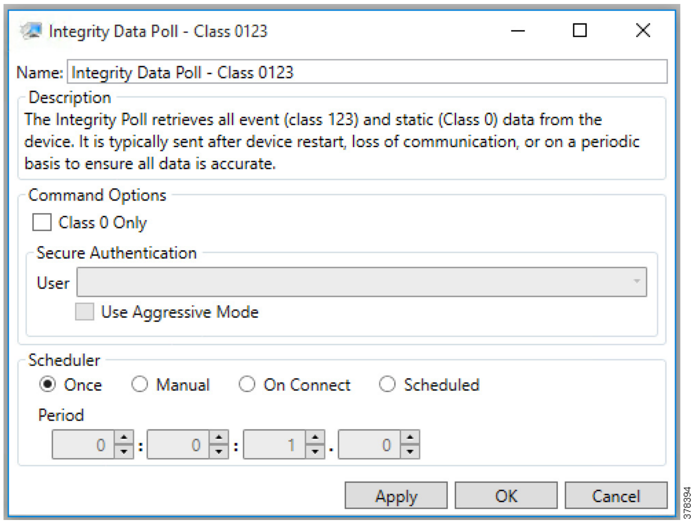
The DNP3 specification supports multiple methods of reading inputs individually or as a group. An integrity poll returns data from Class 0 (known as static data), along with data from Classes 1, 2, and 3 (which will be event data). This may or may not be everything, depending on how the slave is configured.

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 35 Integrity Data Poll



### 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

User

☐ Use Aggressive Mode

Scheduler

● Once ○ Manual ○ On Connect ○ Scheduled

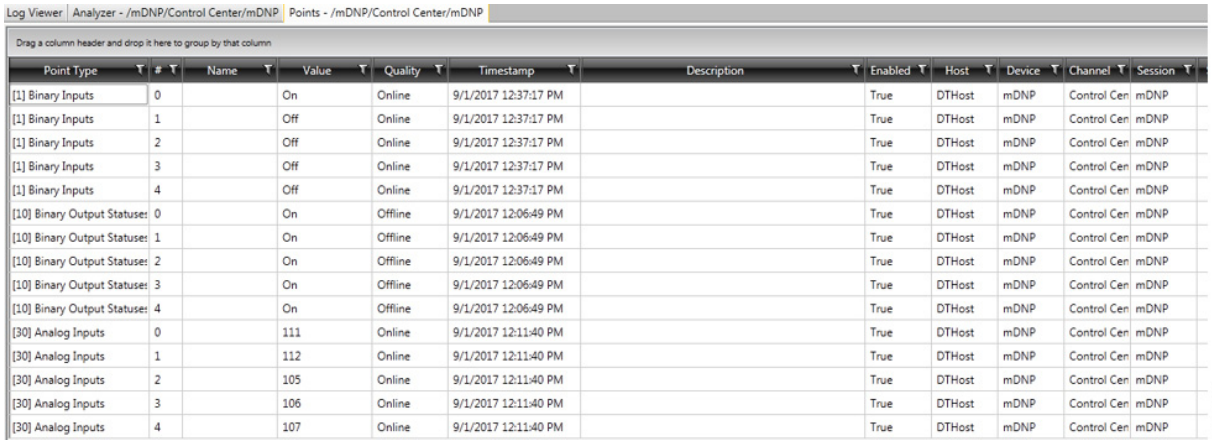
Period

0 : 0 : 1 . 0

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

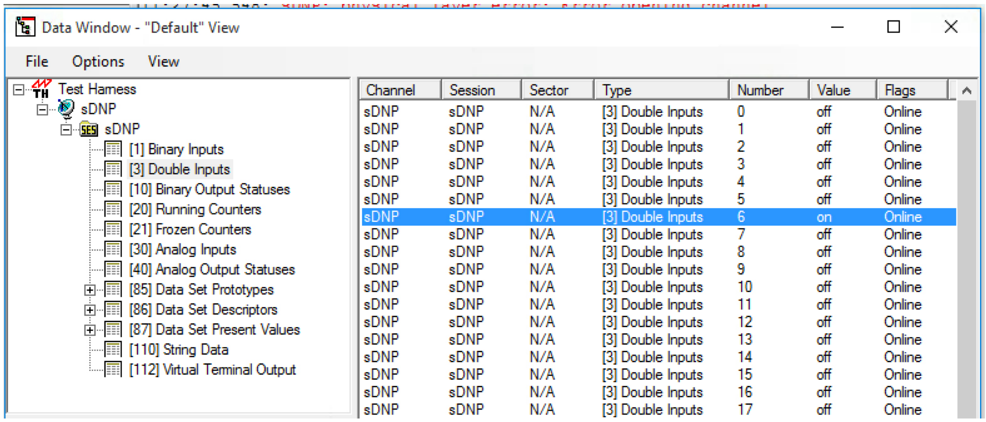

Log Viewer
Analyzer - /mDNP/Control Center/mDNP
Points - /mDNP/Control Center/mDNP
Drag a column header and drop it here to group by that column
378377

| Point Type | # | Name | Value | Quality | Timestamp | Description | Enabled | Host | Device | Channel | Session |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [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 Statuses | 0 | | On | Offline | 9/1/2017 12:06:49 PM | | True | DTHost | mDNP | Control Cen | mDNP |
| [10] Binary Output Statuses | 1 | | On | Offline | 9/1/2017 12:06:49 PM | | True | DTHost | mDNP | Control Cen | mDNP |
| [10] Binary Output Statuses | 2 | | On | Offline | 9/1/2017 12:06:49 PM | | True | DTHost | mDNP | Control Cen | mDNP |
| [10] Binary Output Statuses | 3 | | On | Offline | 9/1/2017 12:06:49 PM | | True | DTHost | mDNP | Control Cen | mDNP |
| [10] Binary Output Statuses | 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:

### Figure 38 DNP3 IP Input Registers



| Channel | Session | Sector | Type | Number | Value | Flags |
|---|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [3] Double Inputs | 0 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 1 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 2 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 3 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 4 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 5 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 6 | on | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 7 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 8 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 9 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 10 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 11 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 12 | off | Online |
| 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 |

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

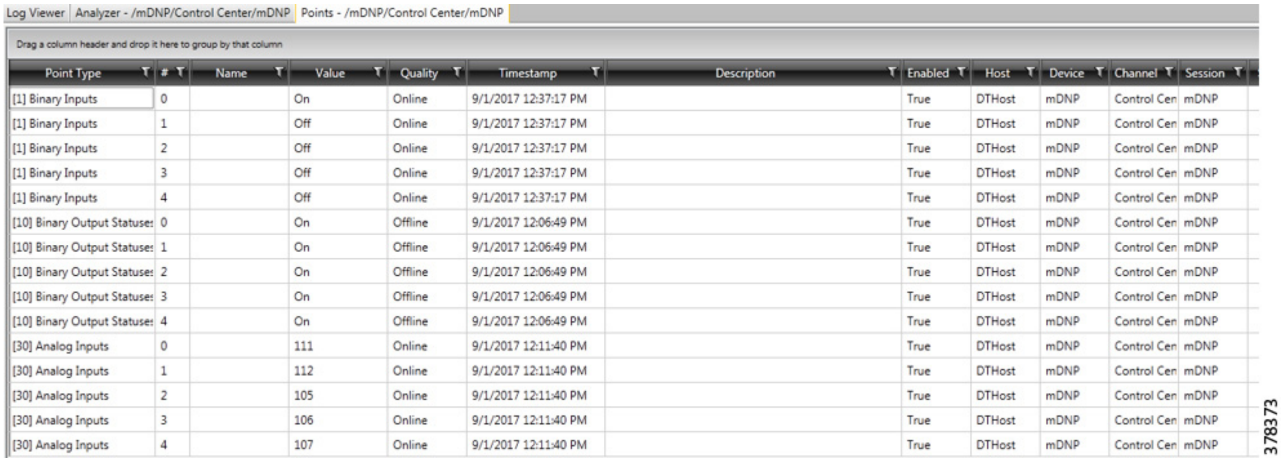
## Unsolicited Reporting

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

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

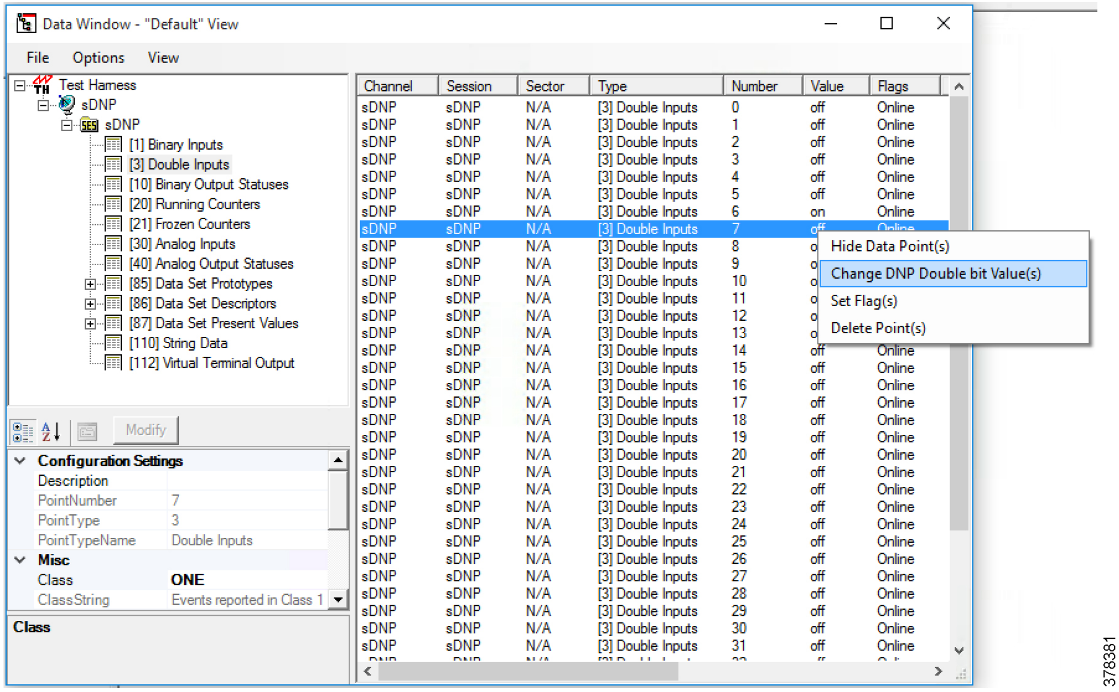


Log Viewer
Analyzer - /mDNP/Control Center/mDNP
Points - /mDNP/Control Center/mDNP
Drag a column header and drop it here to group by that column
378373

| Point Type | # | Name | Value | Quality | Timestamp | Description | Enabled | Host | Device | Channel | Session |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [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 Statuses | 0 | | On | Offline | 9/1/2017 12:06:49 PM | | True | DTHost | mDNP | Control Cen | mDNP |
| [10] Binary Output Statuses | 1 | | On | Offline | 9/1/2017 12:06:49 PM | | True | DTHost | mDNP | Control Cen | mDNP |
| [10] Binary Output Statuses | 2 | | On | Offline | 9/1/2017 12:06:49 PM | | True | DTHost | mDNP | Control Cen | mDNP |
| [10] Binary Output Statuses | 3 | | On | Offline | 9/1/2017 12:06:49 PM | | True | DTHost | mDNP | Control Cen | mDNP |
| [10] Binary Output Statuses | 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 |

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



**Configuration Settings**

| | |
|---|---|
| Description | |
| PointNumber | 7 |
| PointType | 3 |
| PointTypeName | Double Inputs |

**Misc**

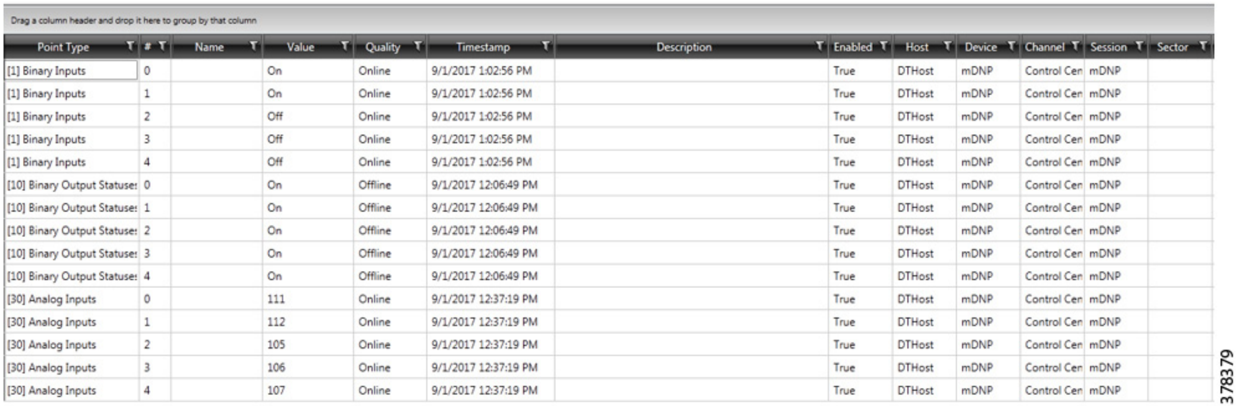
| | |
|---|---|
| Class | ONE |
| ClassString | Events reported in Class 1 |

**Class**

| Channel | Session | Sector | Type | Number | Value | Flags |
|---|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [3] Double Inputs | 0 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 1 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 2 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 3 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 4 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 5 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 6 | on | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 7 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 8 | o | |
| sDNP | sDNP | N/A | [3] Double Inputs | 9 | o | |
| sDNP | sDNP | N/A | [3] Double Inputs | 10 | o | |
| sDNP | sDNP | N/A | [3] Double Inputs | 11 | o | |
| sDNP | sDNP | N/A | [3] Double Inputs | 12 | o | |
| sDNP | sDNP | N/A | [3] Double Inputs | 13 | o | |
| 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 |
| sDNP | sDNP | N/A | [3] Double Inputs | 18 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 19 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 20 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 21 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 22 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 23 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 24 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 25 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 26 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 27 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 28 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 29 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 30 | off | Online |
| sDNP | sDNP | N/A | [3] Double Inputs | 31 | off | Online |

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

### Figure 41 DNP3 Northbound Binary Inputs Register Changed Value



Drag a column header and drop it here to group by that column

| Point Type | # | Name | Value | Quality | Timestamp | Description | Enabled | Host | Device | Channel | Session | Sector |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [1] Binary Inputs | 0 | | On | Online | 9/1/2017 1:02:56 PM | | True | DTHost | mDNP | Control Cen | mDNP | |
| [1] Binary Inputs | 1 | | On | Online | 9/1/2017 1:02:56 PM | | True | DTHost | mDNP | Control Cen | mDNP | |
| [1] Binary Inputs | 2 | | Off | Online | 9/1/2017 1:02:56 PM | | True | DTHost | mDNP | Control Cen | mDNP | |
| [1] Binary Inputs | 3 | | Off | Online | 9/1/2017 1:02:56 PM | | True | DTHost | mDNP | Control Cen | mDNP | |
| [1] Binary Inputs | 4 | | Off | Online | 9/1/2017 1:02:56 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 12:37:19 PM | | True | DTHost | mDNP | Control Cen | mDNP | |
| [30] Analog Inputs | 1 | | 112 | Online | 9/1/2017 12:37:19 PM | | True | DTHost | mDNP | Control Cen | mDNP | |
| [30] Analog Inputs | 2 | | 105 | Online | 9/1/2017 12:37:19 PM | | True | DTHost | mDNP | Control Cen | mDNP | |
| [30] Analog Inputs | 3 | | 106 | Online | 9/1/2017 12:37:19 PM | | True | DTHost | mDNP | Control Cen | mDNP | |
| [30] Analog Inputs | 4 | | 107 | Online | 9/1/2017 12:37:19 PM | | True | DTHost | mDNP | Control Cen | mDNP | |

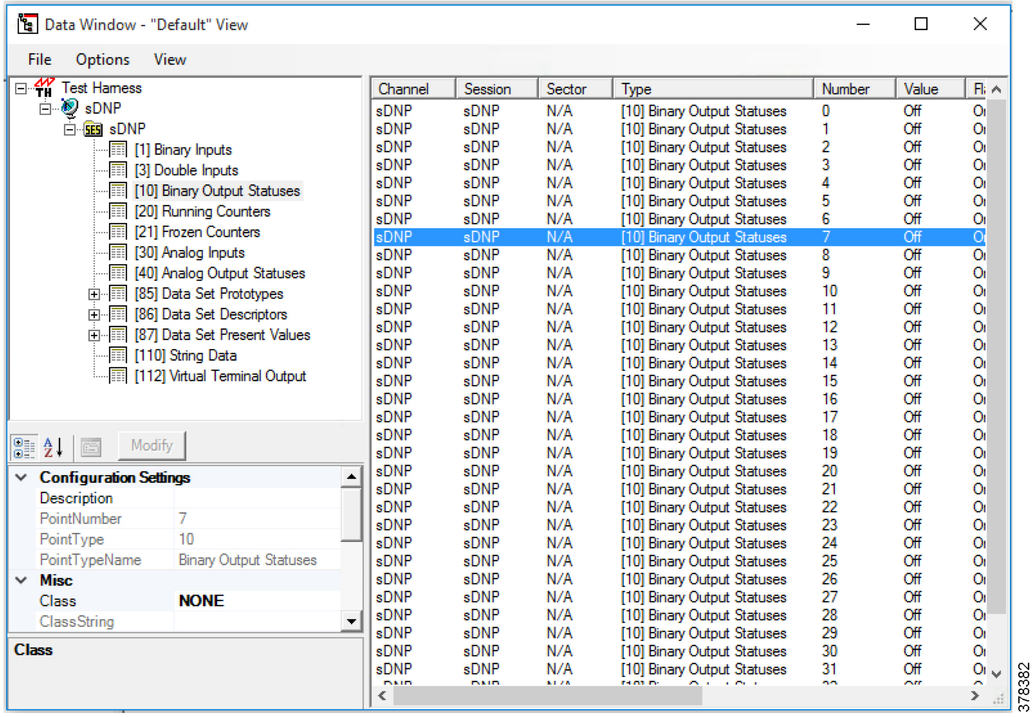
378379

## 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:

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



Configuration Settings

| | |
|---|---|
| Description | |
| PointNumber | 7 |
| PointType | 10 |
| PointTypeName | Binary Output Statuses |

Misc

| | |
|---|---|
| Class | NONE |
| ClassString | |

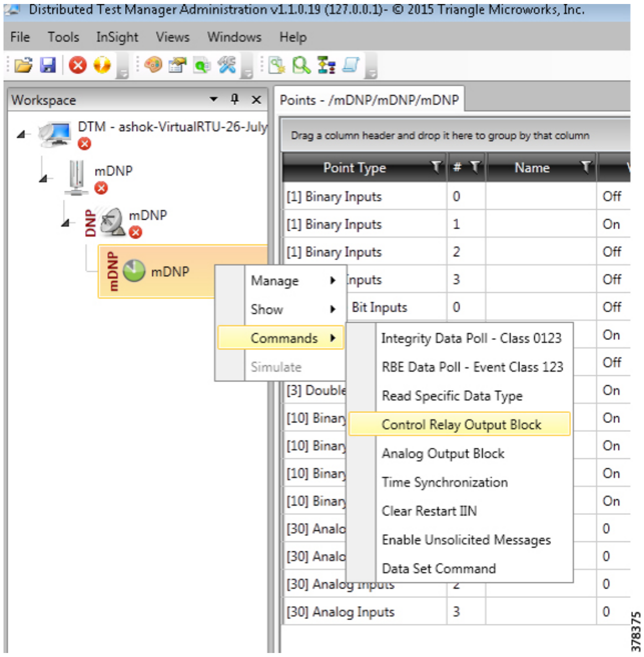
Class

| Channel | Session | Sector | Type | Number | Value | Fl |
|---|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 0 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 1 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 2 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 3 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 4 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 5 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 6 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 7 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 8 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 9 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 10 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 11 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 12 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 13 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 14 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 15 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 16 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 17 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 18 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 19 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 20 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 21 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 22 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 23 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 24 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 25 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 26 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 27 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 28 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 29 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 30 | Off | O |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 31 | Off | O |

378382

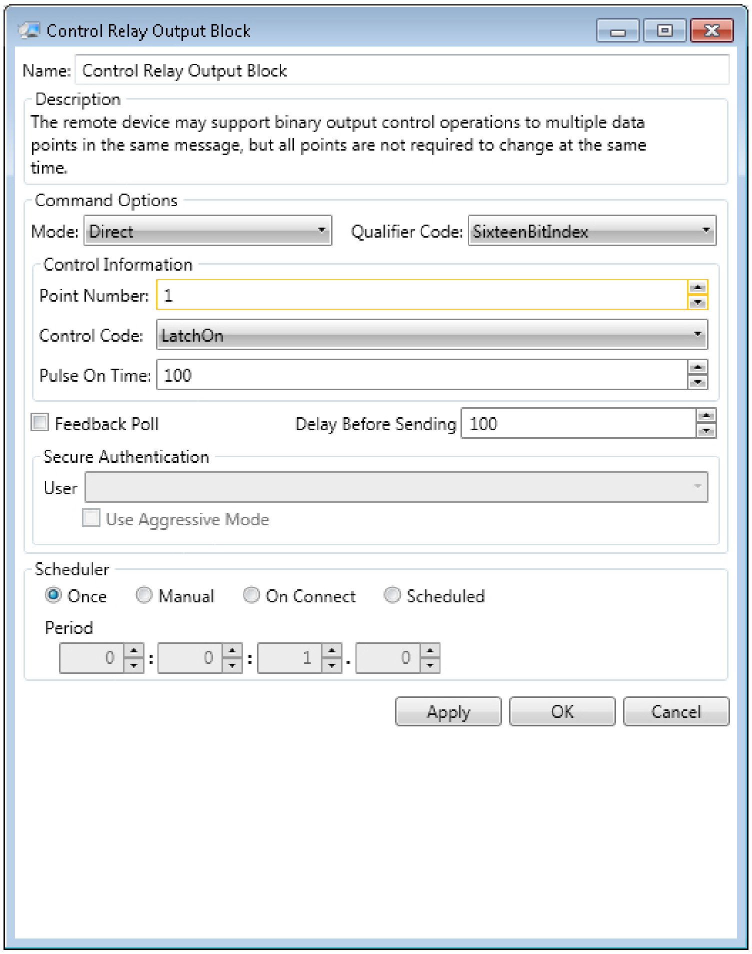
Now we will issue a command from the Northbound simulator to change the state of the register to **ON**.

**Figure 43 DNP3 IP Northbound Control Command**


Distributed Test Manager Administration v1.1.0.19 (127.0.0.1)- © 2015 Triangle Microworks, Inc.
File
Tools
InSight
Views
Windows
Help
Workspace
DTM - ashok-VirtualRTU-26-July
mDNP
DNP
mDNP
mDNP
mDNP
Points - /mDNP/mDNP/mDNP
Drag a column header and drop it here to group by that column
Manage
Show
Commands
Simulate
Integrity Data Poll - Class 0123
RBE Data Poll - Event Class 123
Read Specific Data Type
Control Relay Output Block
Analog Output Block
Time Synchronization
Clear Restart IIN
Enable Unsolicited Messages
Data Set Command
378375

| Point Type | # | Name | V |
|---|---|---|---|
| [1] Binary Inputs | 0 | | Off |
| [1] Binary Inputs | 1 | | On |
| [1] Binary Inputs | 2 | | Off |
| nputs | 3 | | Off |
| Bit Inputs | 0 | | Off |
| | | | On |
| | | | Off |
| [3] Double | | | On |
| [10] Binary | | | On |
| [10] Binary | | | On |
| [10] Binary | | | On |
| [10] Binary | | | On |
| [30] Analo | | | 0 |
| [30] Analo | | | 0 |
| [30] Analog Inputs | 2 | | 0 |
| [30] Analog Inputs | 3 | | 0 |

**Figure 44 DNP3 IP Northbound CROB Control Command**



Control Relay Output Block

Name: Control Relay Output Block

Description

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.

Command Options

Mode: Direct    Qualifier Code: SixteenBitIndex

Control Information

Point Number: 1

Control Code: LatchOn

Pulse On Time: 100

□ Feedback Poll    Delay Before Sending 100

Secure Authentication

User

□ Use Aggressive Mode

Scheduler

● Once ○ Manual ○ On Connect ○ Scheduled

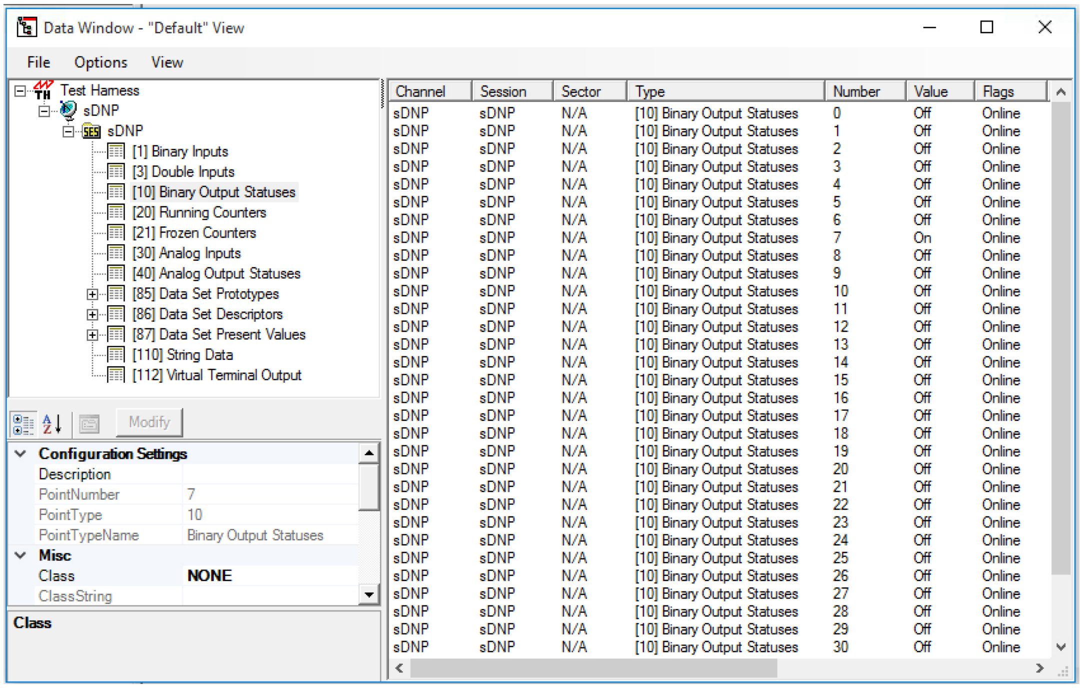
Period 0 : 0 : 1 . 0

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:

**Figure 45 DNP3 Southbound Register Value Changed to ON**



- Test Harness
  - sDNP
    - sDNP
      - [1] Binary Inputs
      - [3] Double Inputs
      - [10] Binary Output Statuses
      - [20] Running Counters
      - [21] Frozen Counters
      - [30] Analog Inputs
      - [40] Analog Output Statuses
      - [85] Data Set Prototypes
      - [86] Data Set Descriptors
      - [87] Data Set Present Values
      - [110] String Data
      - [112] Virtual Terminal Output

| Configuration Settings | |
|---|---|
| Description | |
| PointNumber | 7 |
| PointType | 10 |
| PointTypeName | Binary Output Statuses |
| **Misc** | |
| Class | **NONE** |
| ClassString | |

**Class**

| Channel | Session | Sector | Type | Number | Value | Flags |
|---|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 0 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 1 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 2 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 3 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 4 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 5 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 6 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 7 | On | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 8 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 9 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 10 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 11 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 12 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 13 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 14 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 15 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 16 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 17 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 18 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 19 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 20 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 21 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 22 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 23 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 24 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 25 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 26 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 27 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 28 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 29 | Off | Online |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 30 | Off | Online |

378387

# 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.

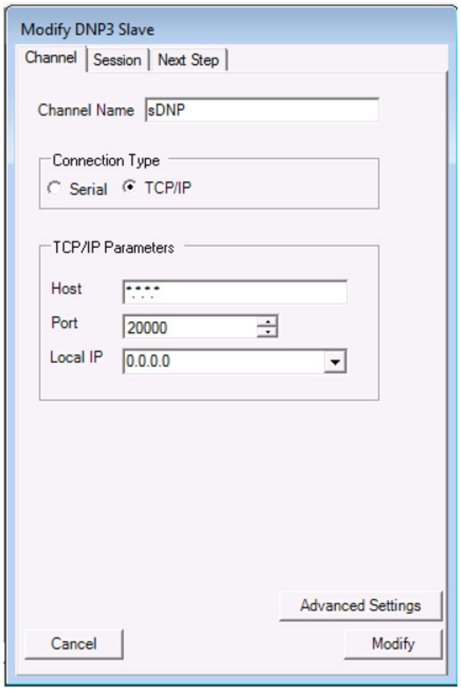
- The Southbound DNP3 IP actuator is simulated using the TMW Test Harness application.
- The Northbound Modbus IP SCADA software is simulated using the TMW DTM application.

## 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:

**Figure 46 DNP3 Southbound DNP3 IP Configuration 1**



Modify DNP3 Slave

Channel Name: sDNP

Connection Type: ○ Serial ● TCP/IP

TCP/IP Parameters

Host: *.*.*.*

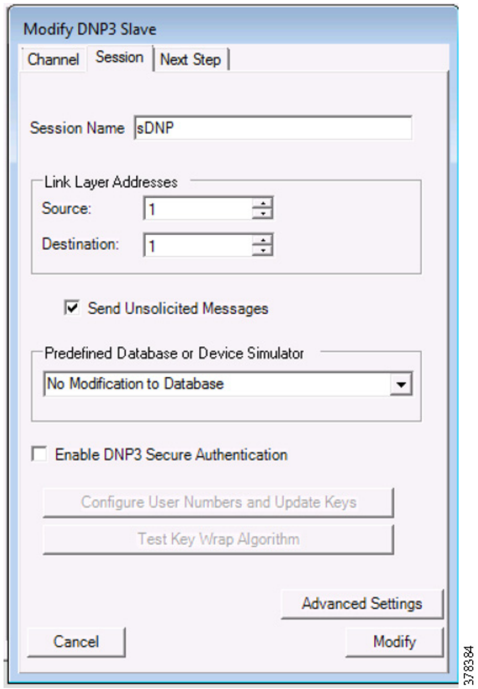
Port: 20000

Local IP: 0.0.0.0

## 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

Session Name: sDNP

Link Layer Addresses

Source: 1

Destination: 1

☑ Send Unsolicited Messages

Predefined Database or Device Simulator: No Modification to Database

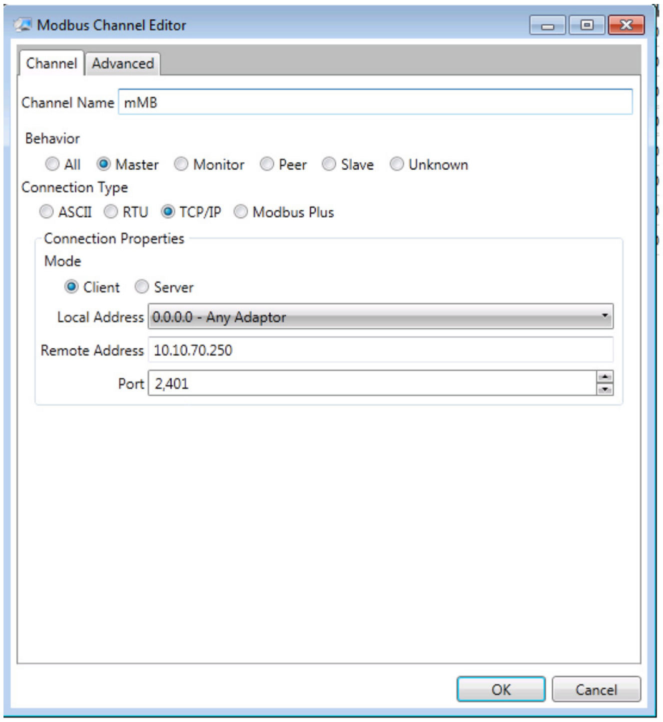
☐ Enable DNP3 Secure Authentication

# 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**



Channel Name mMB

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

# Virtual RTU ES200

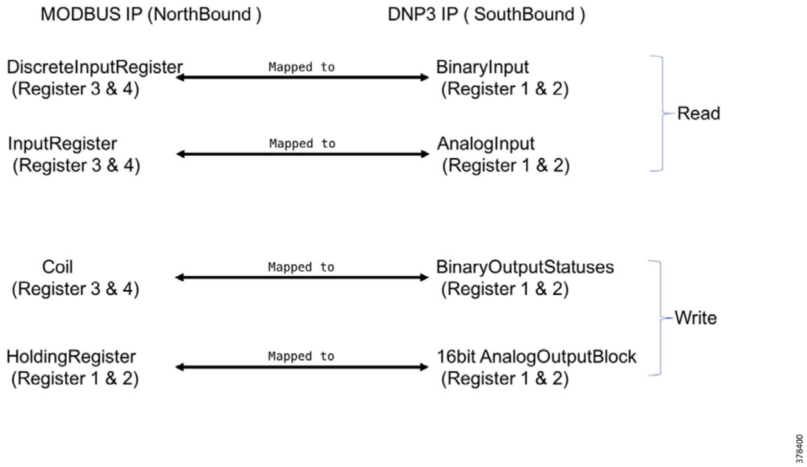
Use the following command to ensure that the corresponding applications are running:

```
DEMO1-89-250-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 -l1
root      1253  0.0  0.6  40916  6060 ?        Ss   Sep27   0:00 /opt/es200/ESRemote -s
/opt/es200/db/racdb.db -L2 -d -l1
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
DEMO1-89-250-GOS-1:~#
```

## 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**

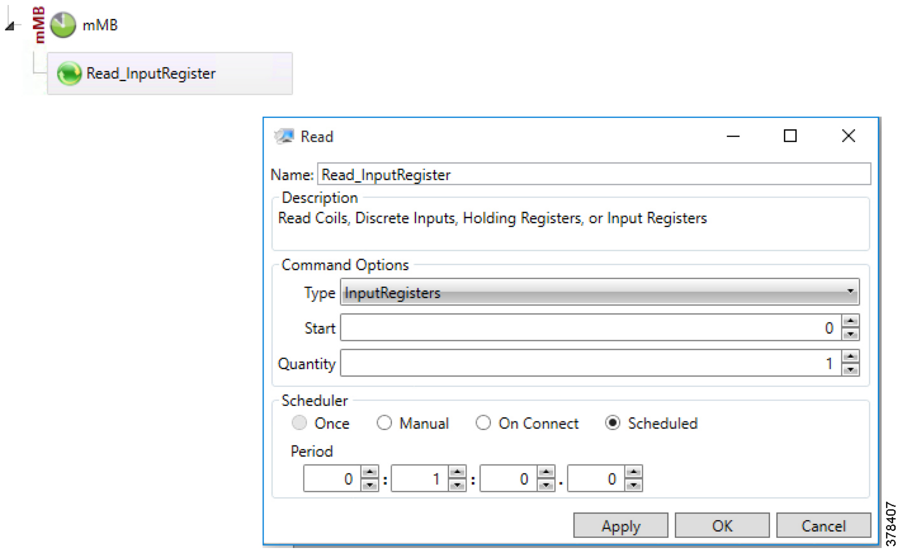

MODBUS IP (NorthBound )
DNP3 IP ( SouthBound )
DiscreteInputRegister (Register 3 & 4)
Mapped to
BinaryInput (Register 1 & 2)
InputRegister (Register 3 & 4)
Mapped to
AnalogInput (Register 1 & 2)
Read
Coil (Register 3 & 4)
Mapped to
BinaryOutputStatuses (Register 1 & 2)
HoldingRegister (Register 1 & 2)
Mapped to
16bit AnalogOutputBlock (Register 1 & 2)
Write
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

**Figure 50 Reading Input Registers**



Read

Name: Read_InputRegister

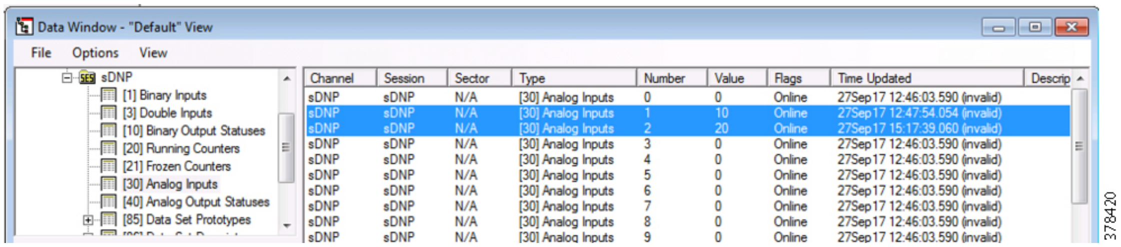
Description
Read Coils, Discrete Inputs, Holding Registers, or Input Registers

Command Options
Type: InputRegisters
Start: 0
Quantity: 1

Scheduler
○ Once ○ Manual ○ On Connect ● Scheduled

Period: 0 : 1 : 0 . 0

**Figure 51 Southbound InputRegisters**



| Channel | Session | Sector | Type | Number | Value | Flags | Time Updated | Descrip |
|---|---|---|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [30] Analog Inputs | 0 | 0 | Online | 27Sep17 12:46:03.590 (invalid) | |
| sDNP | sDNP | N/A | [30] Analog Inputs | 1 | 10 | Online | 27Sep17 12:47:54.054 (invalid) | |
| sDNP | sDNP | N/A | [30] Analog Inputs | 2 | 20 | Online | 27Sep17 15:17:39.060 (invalid) | |
| sDNP | sDNP | N/A | [30] Analog Inputs | 3 | 0 | Online | 27Sep17 12:46:03.590 (invalid) | |
| sDNP | sDNP | N/A | [30] Analog Inputs | 4 | 0 | Online | 27Sep17 12:46:03.590 (invalid) | |
| sDNP | sDNP | N/A | [30] Analog Inputs | 5 | 0 | Online | 27Sep17 12:46:03.590 (invalid) | |
| sDNP | sDNP | N/A | [30] Analog Inputs | 6 | 0 | Online | 27Sep17 12:46:03.590 (invalid) | |
| sDNP | sDNP | N/A | [30] Analog Inputs | 7 | 0 | Online | 27Sep17 12:46:03.590 (invalid) | |
| 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) | |

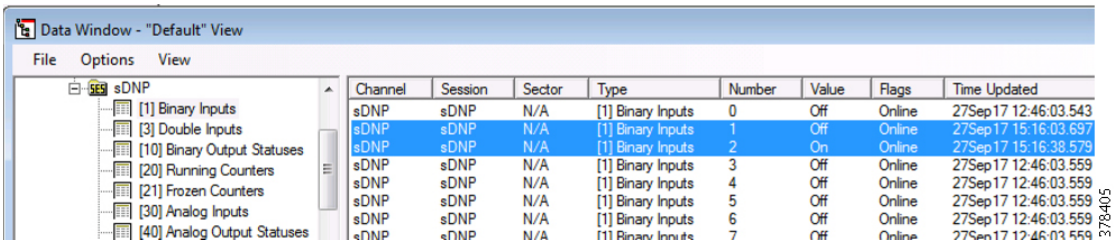
The Southbound DNP3 IP IED AnalogInput 1 and 2 register values are translated to Modbus TCP. We could observe that register values are matching in the Northbound Control Center application.

## 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.

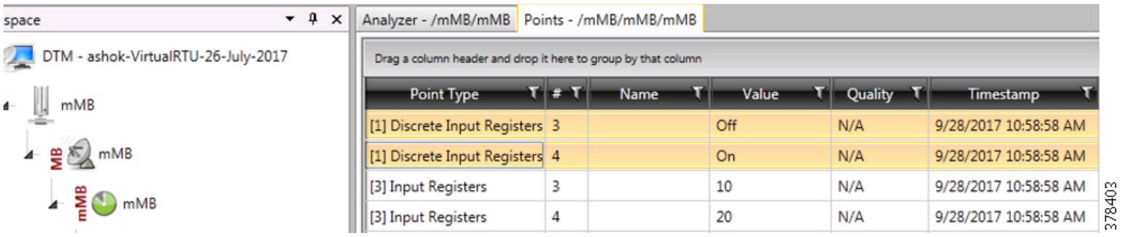
**Figure 52 Present Value at Southbound**



Data Window - "Default" View

| Channel | Session | Sector | Type | Number | Value | Flags | Time Updated |
|---|---|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [1] Binary Inputs | 0 | Off | Online | 27Sep17 12:46:03.543 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 1 | Off | Online | 27Sep17 15:16:03.697 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 2 | On | Online | 27Sep17 15:16:38.579 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 3 | Off | Online | 27Sep17 12:46:03.559 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 4 | Off | Online | 27Sep17 12:46:03.559 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 5 | Off | Online | 27Sep17 12:46:03.559 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 6 | Off | Online | 27Sep17 12:46:03.559 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 7 | Off | Online | 27Sep17 12:46:03.559 |

**Figure 53 Present Value at Northbound**



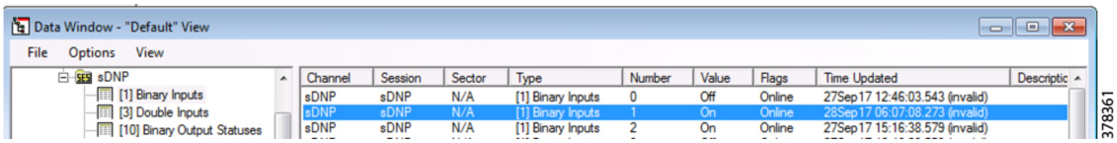
space
DTM - ashok-VirtualRTU-26-July-2017
mMB
MB
mMB
mMB
mMB
Analyzer - /mMB/mMB
Points - /mMB/mMB/mMB
Drag a column header and drop it here to group by that column
378403

| Point Type | # | Name | Value | Quality | Timestamp |
|---|---|---|---|---|---|
| [1] Discrete Input Registers | 3 | | Off | N/A | 9/28/2017 10:58:58 AM |
| [1] Discrete Input Registers | 4 | | On | N/A | 9/28/2017 10:58:58 AM |
| [3] Input Registers | 3 | | 10 | N/A | 9/28/2017 10:58:58 AM |
| [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**



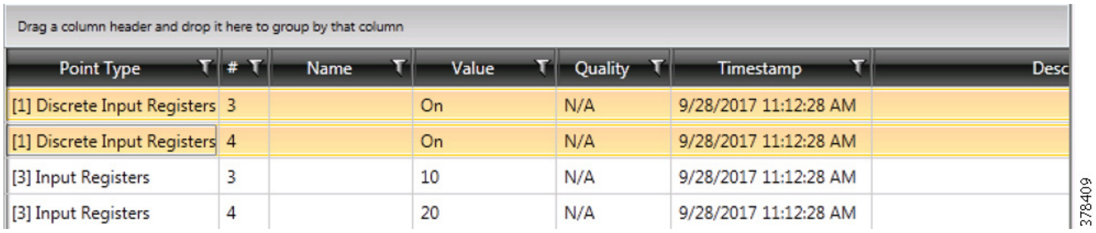
Data Window - "Default" View

| Channel | Session | Sector | Type | Number | Value | Flags | Time Updated | Descriptic |
|---|---|---|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [1] Binary Inputs | 0 | Off | Online | 27Sep17 12:46:03.543 (invalid) | |
| sDNP | sDNP | N/A | [1] Binary Inputs | 1 | On | Online | 28Sep17 06:07:08.273 (invalid) | |
| sDNP | sDNP | N/A | [1] Binary Inputs | 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

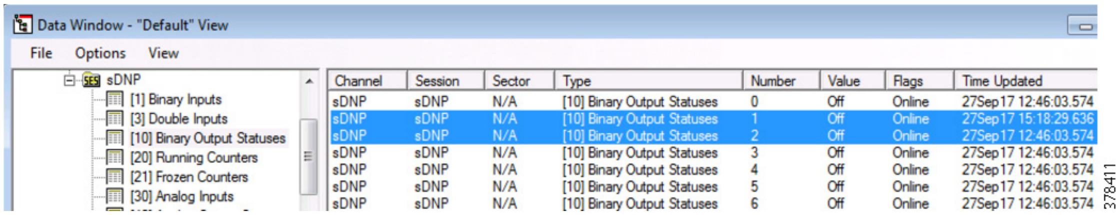
| Point Type | # | Name | Value | Quality | Timestamp | Desc |
|---|---|---|---|---|---|---|
| [1] Discrete Input Registers | 3 | | On | N/A | 9/28/2017 11:12:28 AM | |
| [1] Discrete Input Registers | 4 | | On | N/A | 9/28/2017 11:12:28 AM | |
| [3] Input Registers | 3 | | 10 | N/A | 9/28/2017 11:12:28 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:

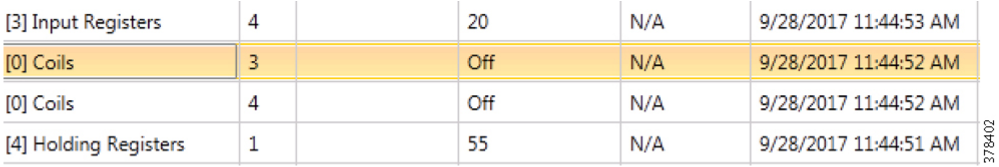
**Figure 56 Register Value Changes Status at Southbound**



| Channel | Session | Sector | Type | Number | Value | Flags | Time Updated |
|---|---|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 0 | Off | Online | 27Sep17 12:46:03.574 |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 1 | Off | Online | 27Sep17 15:18:29.636 |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 2 | Off | Online | 27Sep17 12:46:03.574 |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 3 | Off | Online | 27Sep17 12:46:03.574 |
| 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 |

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**.

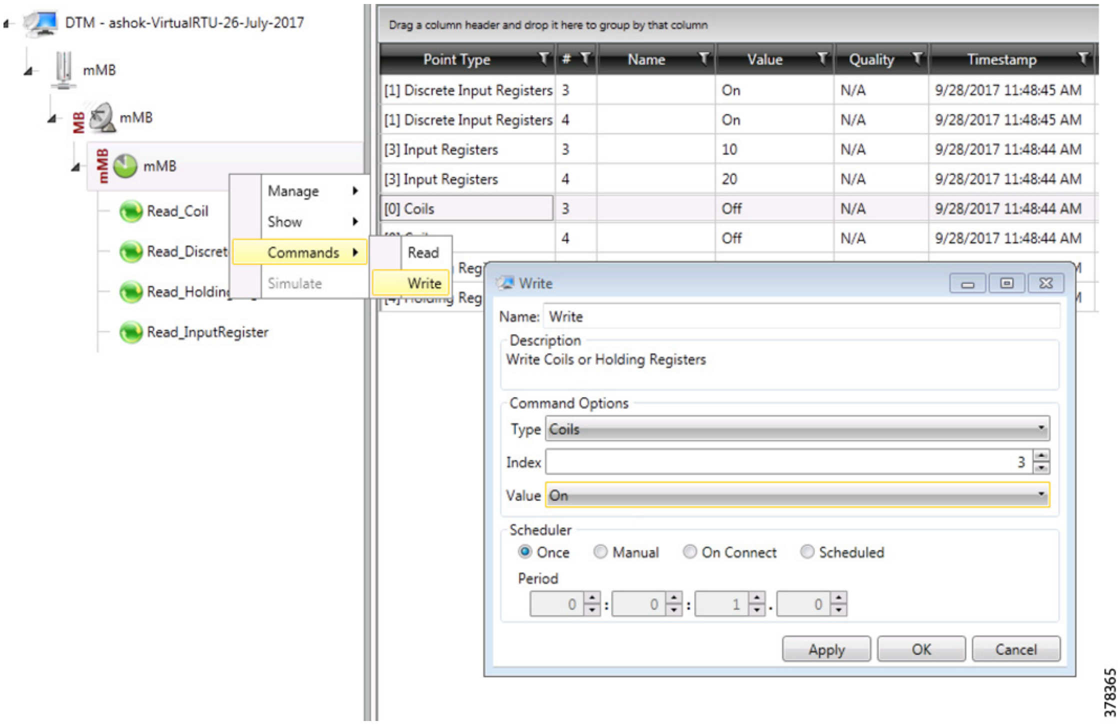
**Figure 57 Present Coil Register 3 Value**



| | | | | | |
|---|---|---|---|---|---|
| [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 |

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

### Figure 58 Command to Toggle Coil Register 3 Value



| Point Type | # | Name | Value | Quality | Timestamp |
|---|---|---|---|---|---|
| [1] Discrete Input Registers | 3 | | On | N/A | 9/28/2017 11:48:45 AM |
| [1] Discrete Input Registers | 4 | | On | N/A | 9/28/2017 11:48:45 AM |
| [3] Input Registers | 3 | | 10 | N/A | 9/28/2017 11:48:44 AM |
| [3] Input Registers | 4 | | 20 | N/A | 9/28/2017 11:48:44 AM |
| [0] Coils | 3 | | Off | N/A | 9/28/2017 11:48:44 AM |
| | 4 | | Off | N/A | 9/28/2017 11:48:44 AM |

Write

Name: Write

Description
Write Coils or Holding Registers

Command Options
Type: Coils
Index: 3
Value: On

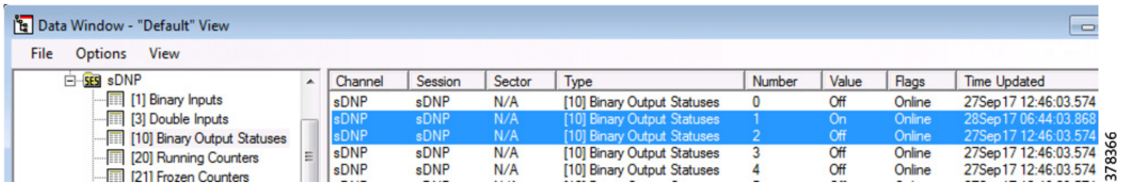
Scheduler
● Once ○ Manual ○ On Connect ○ Scheduled

Period 0 : 0 : 1 . 0

Apply OK Cancel

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:

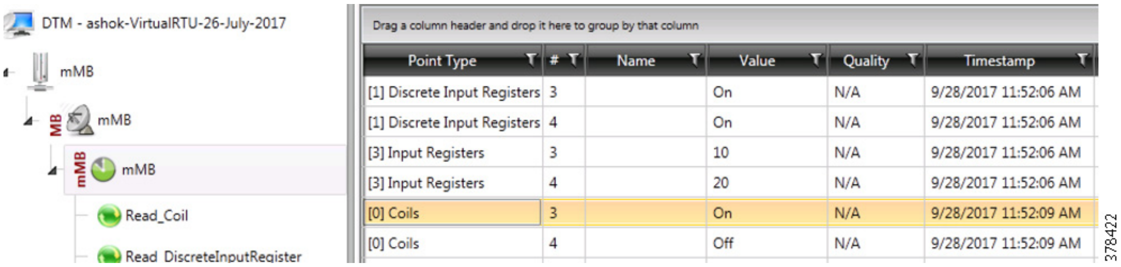
### Figure 59 Command to Toggle Coil Register 1 Value



| Channel | Session | Sector | Type | Number | Value | Flags | Time Updated |
|---|---|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 0 | Off | Online | 27Sep17 12:46:03.574 |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 1 | On | Online | 28Sep17 06:44:03.868 |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 2 | Off | Online | 27Sep17 12:46:03.574 |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 3 | Off | Online | 27Sep17 12:46:03.574 |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 4 | Off | Online | 27Sep17 12:46:03.574 |

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

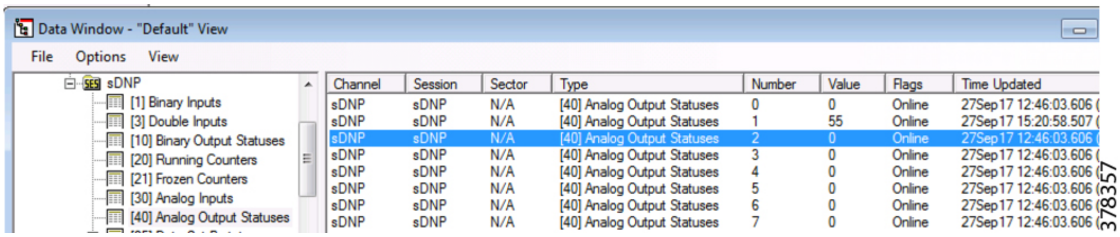

DTM - ashok-VirtualRTU-26-July-2017
mMB
mMB
mMB
Read_Coil
Read_DiscreteInputRegister
Drag a column header and drop it here to group by this column
378422

| Point Type | # | Name | Value | Quality | Timestamp |
|---|---|---|---|---|---|
| [1] Discrete Input Registers | 3 | | On | N/A | 9/28/2017 11:52:06 AM |
| [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 |
| [0] Coils | 3 | | On | N/A | 9/28/2017 11:52:09 AM |
| [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

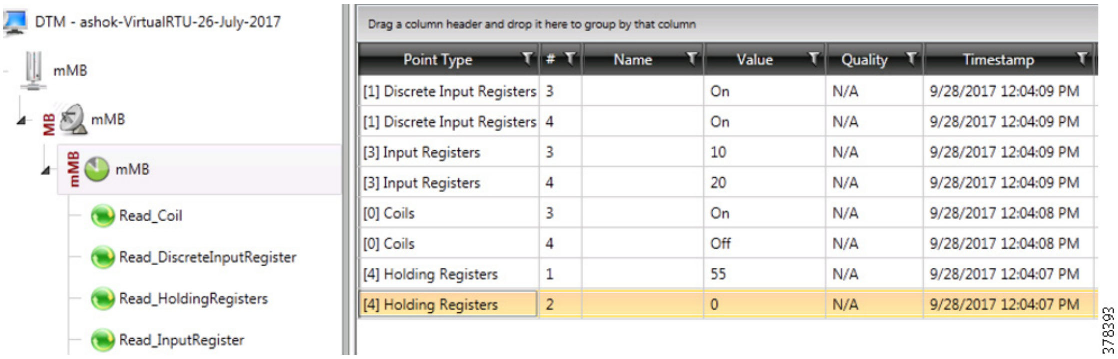


| Channel | Session | Sector | Type | Number | Value | Flags | Time Updated |
|---|---|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 0 | 0 | Online | 27Sep17 12:46:03.606 ( |
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 1 | 55 | Online | 27Sep17 15:20:58.507 ( |
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 2 | 0 | Online | 27Sep17 12:46:03.606 ( |
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 3 | 0 | Online | 27Sep17 12:46:03.606 ( |
| 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 ( |
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 6 | 0 | Online | 27Sep17 12:46:03.606 ( |
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 7 | 0 | Online | 27Sep17 12:46:03.606 ( |

## Present HoldingRegister 2 Value at Northbound

See Figure 62:

### Figure 62 Holding Register Present Value

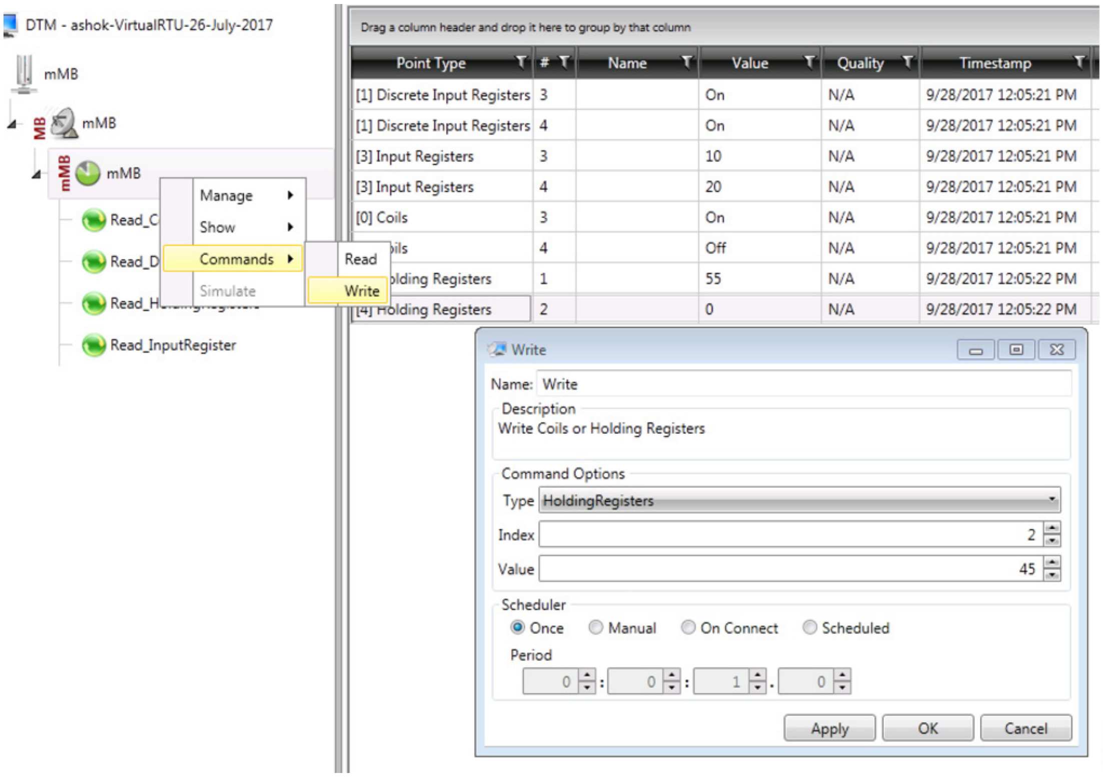

DTM - ashok-VirtualRTU-26-July-2017
mMB
MB
mMB
mMB
mMB
Read_Coil
Read_DiscreteInputRegister
Read_HoldingRegisters
Read_InputRegister
Drag a column header and drop it here to group by that column
378393

| Point Type | # | Name | Value | Quality | Timestamp |
|---|---|---|---|---|---|
| [1] Discrete Input Registers | 3 | | On | N/A | 9/28/2017 12:04:09 PM |
| [1] Discrete Input Registers | 4 | | On | N/A | 9/28/2017 12:04:09 PM |
| [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 |
| [0] Coils | 3 | | On | N/A | 9/28/2017 12:04:08 PM |
| [0] Coils | 4 | | Off | N/A | 9/28/2017 12:04:08 PM |
| [4] Holding Registers | 1 | | 55 | N/A | 9/28/2017 12:04:07 PM |
| [4] Holding Registers | 2 | | 0 | N/A | 9/28/2017 12:04:07 PM |

## Changing Holding Register 2 Value

See Figure 63:

**Figure 63 Command to Change Holding Register Value**



Drag a column header and drop it here to group by that column

| Point Type | # | Name | Value | Quality | Timestamp |
|---|---|---|---|---|---|
| [1] Discrete Input Registers | 3 | | On | N/A | 9/28/2017 12:05:21 PM |
| [1] Discrete Input Registers | 4 | | On | N/A | 9/28/2017 12:05:21 PM |
| [3] Input Registers | 3 | | 10 | N/A | 9/28/2017 12:05:21 PM |
| [3] Input Registers | 4 | | 20 | N/A | 9/28/2017 12:05:21 PM |
| [0] Coils | 3 | | On | N/A | 9/28/2017 12:05:21 PM |
| ils | 4 | | Off | N/A | 9/28/2017 12:05:21 PM |
| olding Registers | 1 | | 55 | N/A | 9/28/2017 12:05:22 PM |
| [4] Holding Registers | 2 | | 0 | N/A | 9/28/2017 12:05:22 PM |

Write

Name: Write

Description
Write Coils or Holding Registers

Command Options
Type: HoldingRegisters
Index: 2
Value: 45

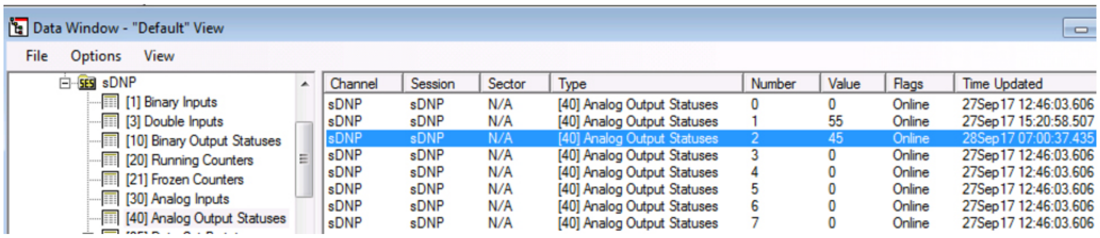
Scheduler
● Once ○ Manual ○ On Connect ○ Scheduled

Period: 0 : 0 : 1 . 0

Apply OK Cancel

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

**Figure 64 Changes Reflected at Southbound Output Register**

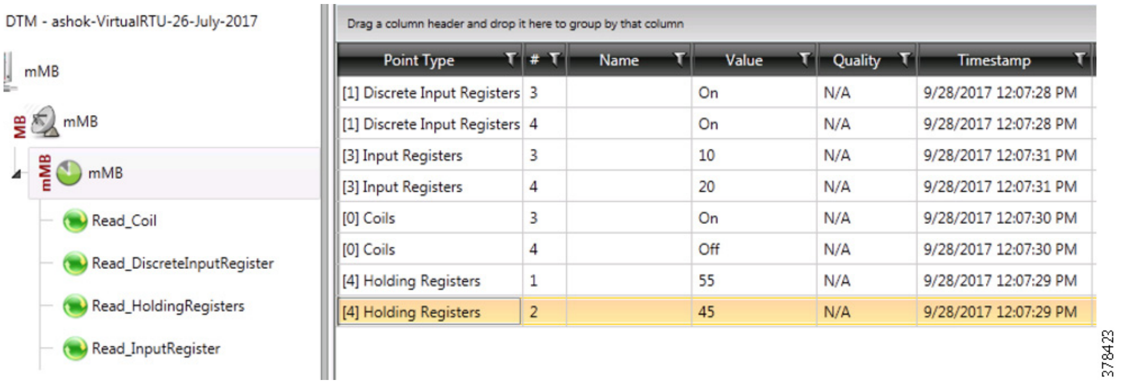


Data Window - "Default" View

| Channel | Session | Sector | Type | Number | Value | Flags | Time Updated |
|---|---|---|---|---|---|---|---|
| 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 |
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 2 | 45 | Online | 28Sep17 07:00:37.435 |
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 3 | 0 | Online | 27Sep17 12:46:03.606 |
| 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 |
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 6 | 0 | Online | 27Sep17 12:46:03.606 |
| 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
mMB
MB
mMB
mMB
mMB
Read_Coil
Read_DiscreteInputRegister
Read_HoldingRegisters
Read_InputRegister
Drag a column header and drop it here to group by that column
378423

| Point Type | # | Name | Value | Quality | Timestamp |
|---|---|---|---|---|---|
| [1] Discrete Input Registers | 3 | | On | N/A | 9/28/2017 12:07:28 PM |
| [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 |
| [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 |
| [4] Holding Registers | 1 | | 55 | N/A | 9/28/2017 12:07:29 PM |
| [4] Holding Registers | 2 | | 45 | N/A | 9/28/2017 12:07:29 PM |

# 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

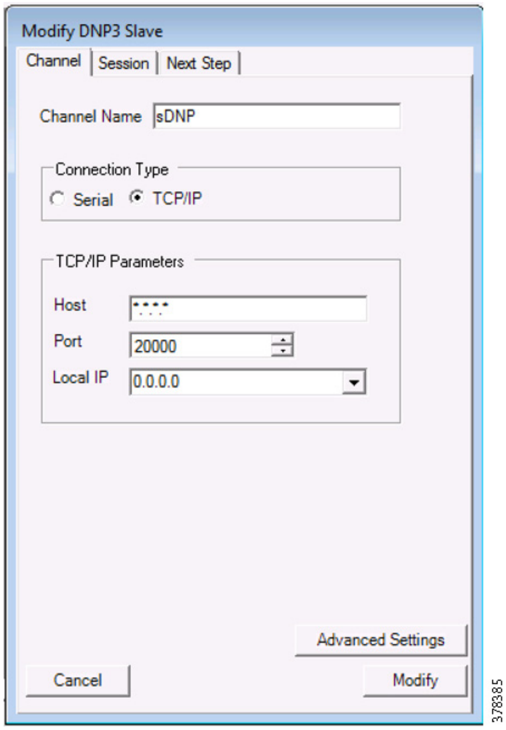
### Channel Configuration

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



Channel Name: sDNP

Connection Type
○ Serial ● TCP/IP

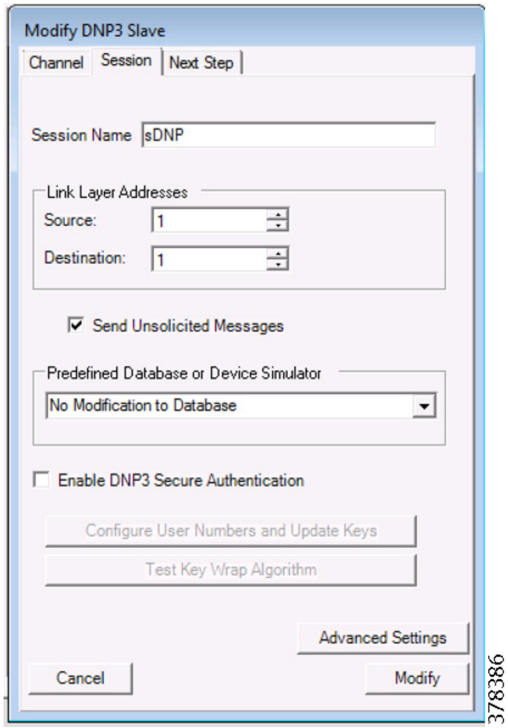
TCP/IP Parameters

Host: . . . .

Port: 20000

Local IP: 0.0.0.0

### Figure 67 DNP3 Southbound DNP3 Session Configuration



Session Name: sDNP

Link Layer Addresses

Source: 1

Destination: 1

☑ Send Unsolicited Messages

Predefined Database or Device Simulator: No Modification to Database

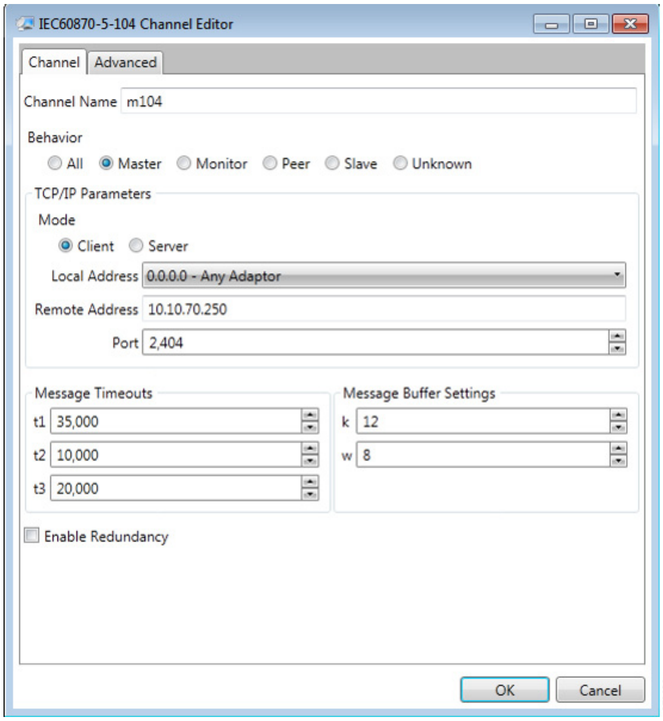
□ Enable DNP3 Secure Authentication

# 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:

**Figure 68 Northbound T104 Configuration**



IEC60870-5-104 Channel Editor

Channel Name m104

Behavior

○ All ● Master ○ Monitor ○ Peer ○ Slave ○ Unknown

TCP/IP Parameters

Mode

● Client ○ Server

Local Address 0.0.0.0 - Any Adaptor

Remote Address 10.10.70.250

Port 2,404

Message Timeouts

t1 35,000

t2 10,000

t3 20,000

Message Buffer Settings

k 12

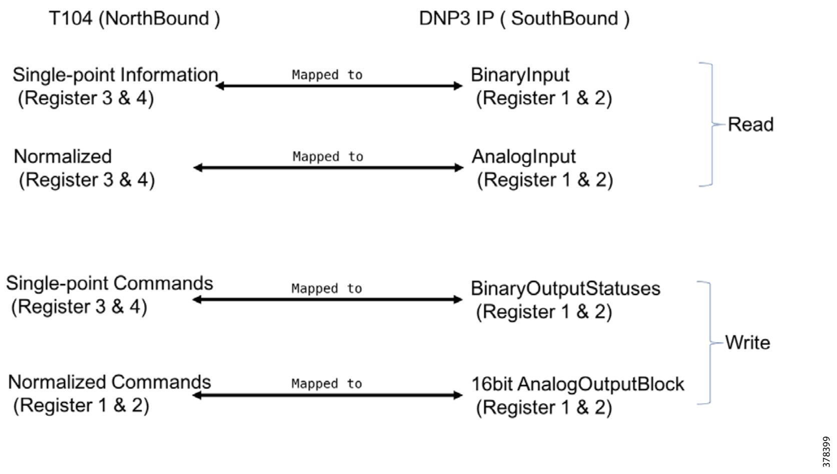
w 8

□ Enable Redundancy

## 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**



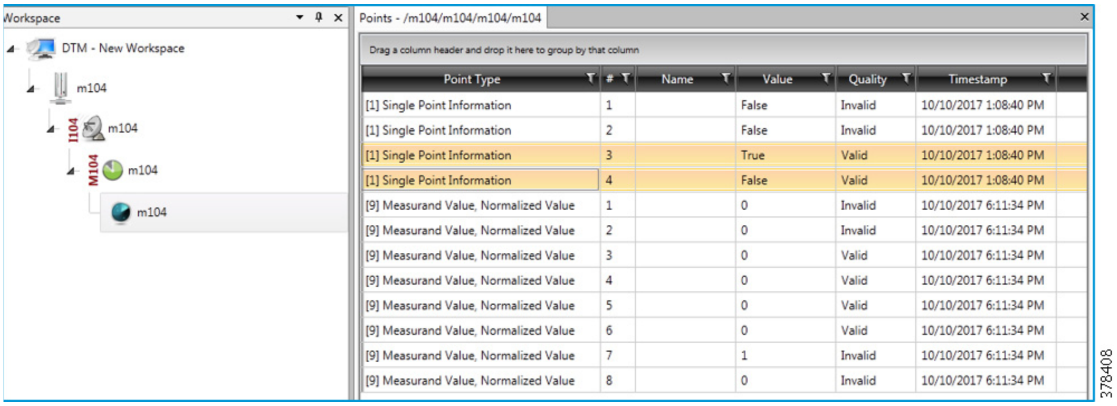
# Reading DNP3 Southbound Data from Northbound T104 Control Center

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

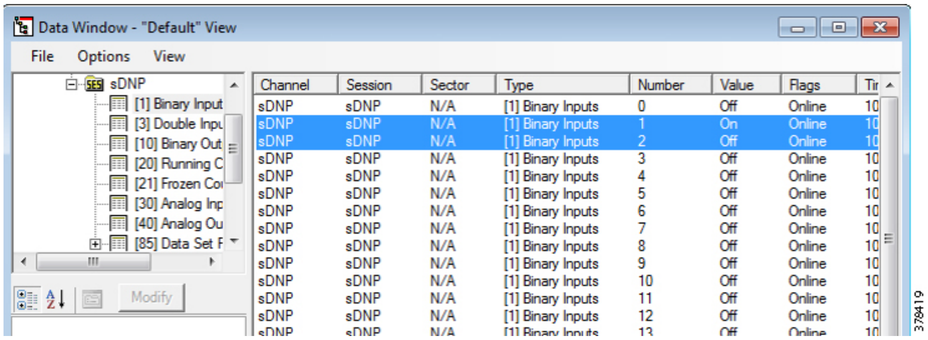
See Figure 70 and Figure 71:

**Figure 70 Reading Single Point Information**


Workspace
DTM - New Workspace
m104
I104
m104
M104
m104
m104
Points - /m104/m104/m104/m104
Drag a column header and drop it here to group by that column
378408

| Point Type | # | Name | Value | Quality | Timestamp |
|---|---|---|---|---|---|
| [1] Single Point Information | 1 | | False | Invalid | 10/10/2017 1:08:40 PM |
| [1] Single Point Information | 2 | | False | Invalid | 10/10/2017 1:08:40 PM |
| [1] Single Point Information | 3 | | True | Valid | 10/10/2017 1:08:40 PM |
| [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 71 Southbound Binary InputRegisters**



| Channel | Session | Sector | Type | Number | Value | Flags | Tir |
|---|---|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [1] Binary Inputs | 0 | Off | Online | 10 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 1 | On | Online | 10 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 2 | Off | Online | 10 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 3 | Off | Online | 10 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 4 | Off | Online | 10 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 5 | Off | Online | 10 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 6 | Off | Online | 10 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 7 | Off | Online | 10 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 8 | Off | Online | 10 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 9 | Off | Online | 10 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 10 | Off | Online | 10 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 11 | Off | Online | 10 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 12 | Off | Online | 10 |
| sDNP | sDNP | N/A | [1] Binary Inputs | 13 | Off | Online | 10 |

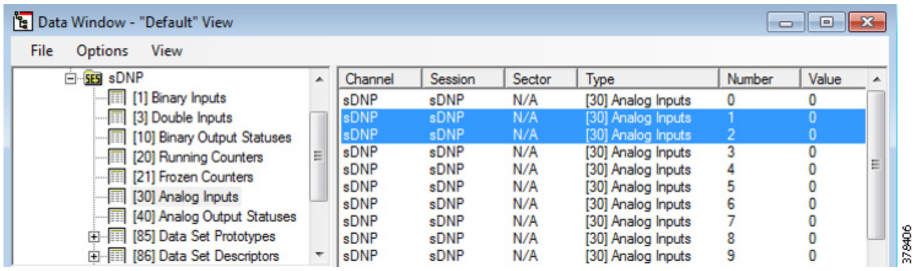
The Southbound DNP3 IP IED BinaryInput 1 and 2 register values are translated to T104 and we could observe register values are matching in the Northbound Control Center application.

## Unsolicited Reporting

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

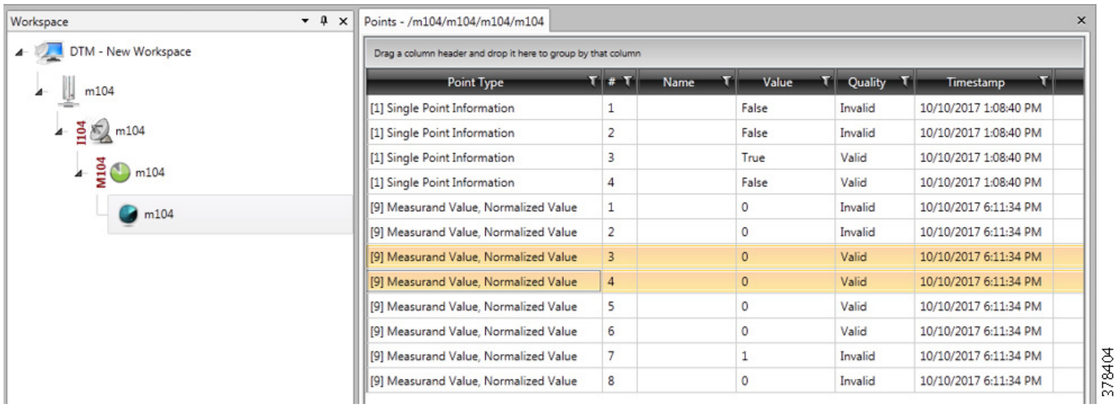
In the example shown in Figure 72 and Figure 73, we are changing the AnalogInput Register 1 and 2 in the Southbound application and checking that the state of normalized 3 and 4 values in the Northbound DTM application are dynamically updated.

### Figure 72 Present Value at Southbound



| Channel | Session | Sector | Type | Number | Value |
|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [30] Analog Inputs | 0 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 1 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 2 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 3 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 4 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 5 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 6 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 7 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 8 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 9 | 0 |

### Figure 73 Present Value at Northbound



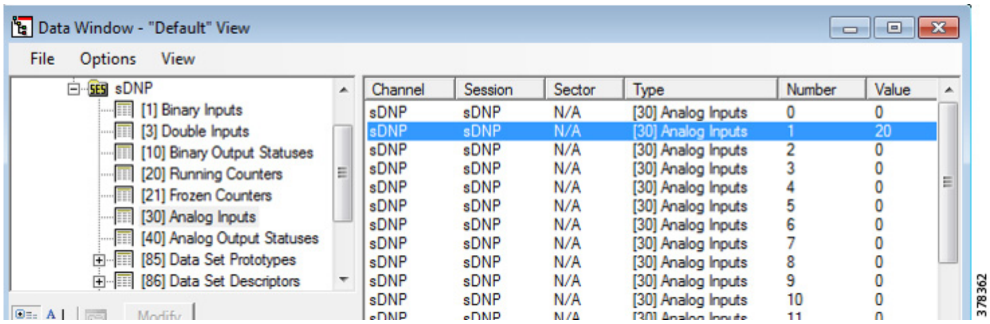
Workspace
DTM - New Workspace
m104
I104
m104
M104
m104
m104
Points - /m104/m104/m104/m104
Drag a column header and drop it here to group by that column
378404

| Point Type | # | Name | Value | Quality | Timestamp |
|---|---|---|---|---|---|
| [1] Single Point Information | 1 | | False | Invalid | 10/10/2017 1:08:40 PM |
| [1] Single Point Information | 2 | | False | Invalid | 10/10/2017 1:08:40 PM |
| [1] Single Point Information | 3 | | True | Valid | 10/10/2017 1:08:40 PM |
| [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 |

## 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

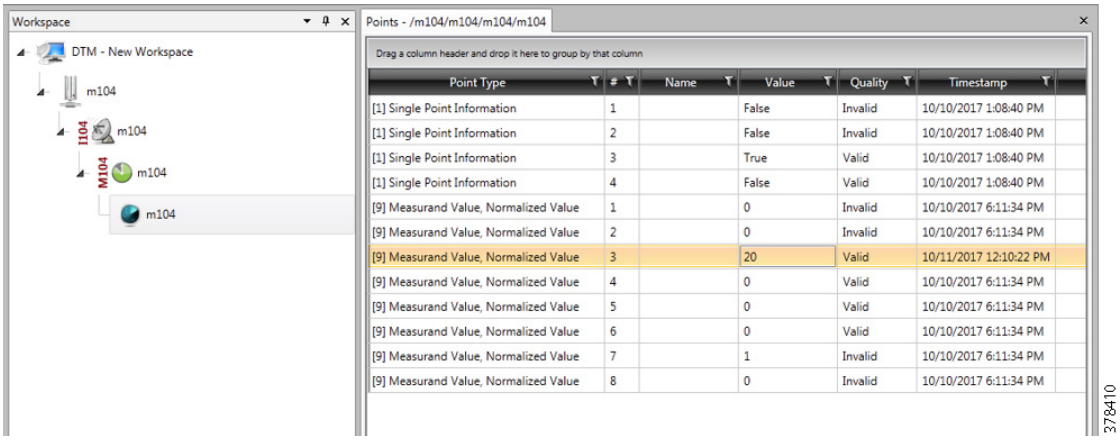


| Channel | Session | Sector | Type | Number | Value |
|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [30] Analog Inputs | 0 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 1 | 20 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 2 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 3 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 4 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 5 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 6 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 7 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 8 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 9 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 10 | 0 |
| sDNP | sDNP | N/A | [30] Analog Inputs | 11 | 0 |

## Dynamically Updated Northbound Values

See Figure 75:

Figure 75 Register Value Changes at Northbound

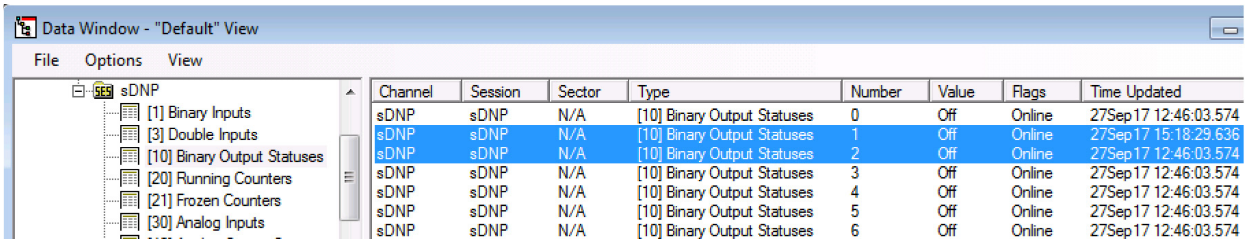

Workspace
DTM - New Workspace
m104
I104
m104
M104
m104
m104
Points - /m104/m104/m104/m104
Drag a column header and drop it here to group by that column
378410

| Point Type | # | Name | Value | Quality | Timestamp |
|---|---|---|---|---|---|
| [1] Single Point Information | 1 | | False | Invalid | 10/10/2017 1:08:40 PM |
| [1] Single Point Information | 2 | | False | Invalid | 10/10/2017 1:08:40 PM |
| [1] Single Point Information | 3 | | True | Valid | 10/10/2017 1:08:40 PM |
| [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 | | 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:

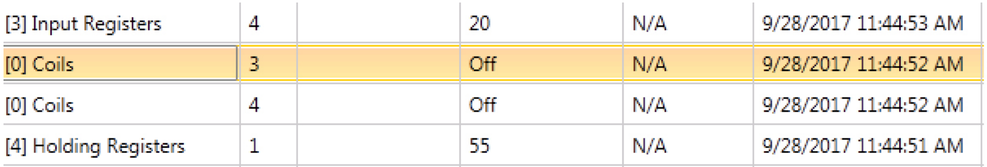
### Figure 76 Register Value Changes Status at Southbound



| Channel | Session | Sector | Type | Number | Value | Flags | Time Updated |
|---|---|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 0 | Off | Online | 27Sep17 12:46:03.574 |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 1 | Off | Online | 27Sep17 15:18:29.636 |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 2 | Off | Online | 27Sep17 12:46:03.574 |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 3 | Off | Online | 27Sep17 12:46:03.574 |
| 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**.

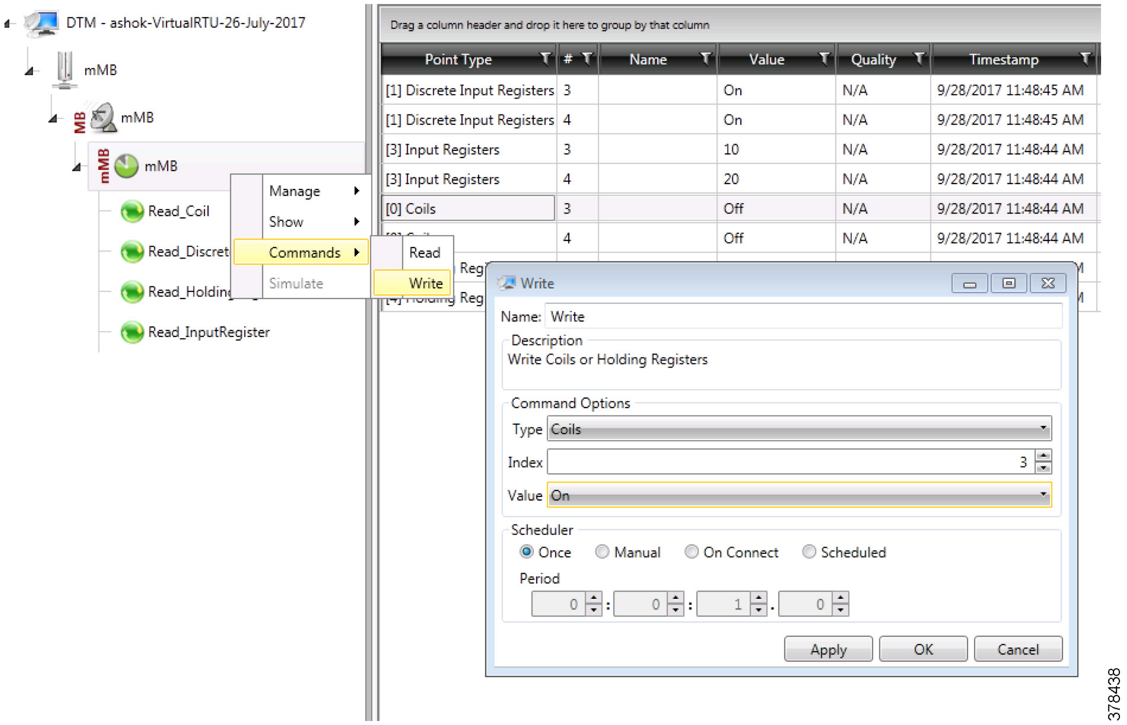
### Figure 77 Present Single Point Command Register 3 Value



| | | | | | |
|---|---|---|---|---|---|
| [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 |
| [4] Holding Registers | 1 | | 55 | N/A | 9/28/2017 11:44:51 AM |

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

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



| Point Type | # | Name | Value | Quality | Timestamp |
|---|---|---|---|---|---|
| [1] Discrete Input Registers | 3 | | On | N/A | 9/28/2017 11:48:45 AM |
| [1] Discrete Input Registers | 4 | | On | N/A | 9/28/2017 11:48:45 AM |
| [3] Input Registers | 3 | | 10 | N/A | 9/28/2017 11:48:44 AM |
| [3] Input Registers | 4 | | 20 | N/A | 9/28/2017 11:48:44 AM |
| [0] Coils | 3 | | Off | N/A | 9/28/2017 11:48:44 AM |
| | 4 | | Off | N/A | 9/28/2017 11:48:44 AM |

Write

Name: Write

Description: Write Coils or Holding Registers

Command Options

Type: Coils

Index: 3

Value: On

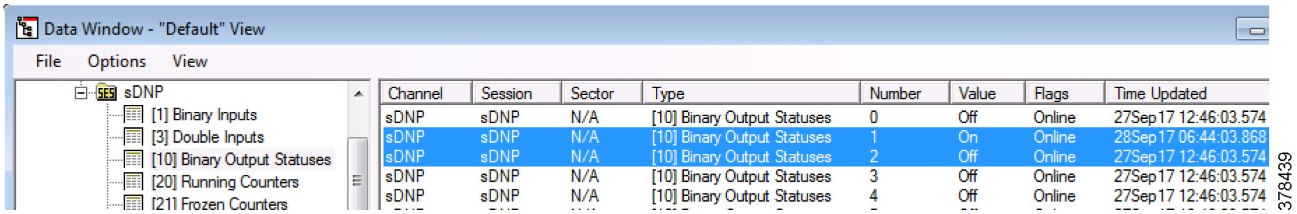
Scheduler: ● Once ○ Manual ○ On Connect ○ Scheduled

Period: 0 : 0 : 1 . 0

Apply OK Cancel

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:

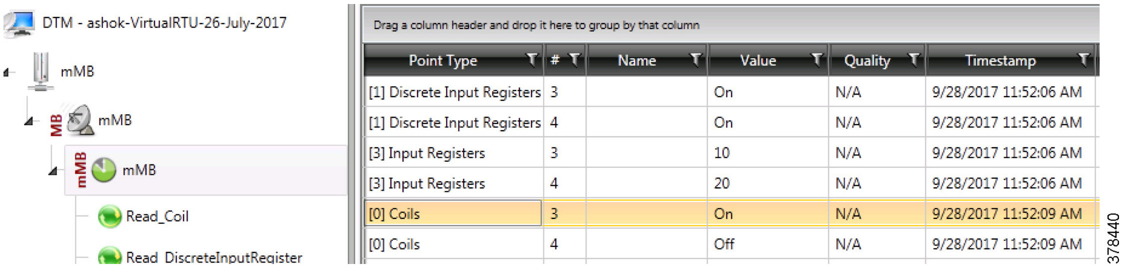
### Figure 79 Command to Toggle Single Point Command Register 1



| Channel | Session | Sector | Type | Number | Value | Flags | Time Updated |
|---|---|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 0 | Off | Online | 27Sep17 12:46:03.574 |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 1 | On | Online | 28Sep17 06:44:03.868 |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 2 | Off | Online | 27Sep17 12:46:03.574 |
| sDNP | sDNP | N/A | [10] Binary Output Statuses | 3 | Off | Online | 27Sep17 12:46:03.574 |
| 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**



DTM - ashok-VirtualRTU-26-July-2017
- mMB
  - mMB
    - mMB
      - Read_Coil
      - Read_DiscreteInputRegister

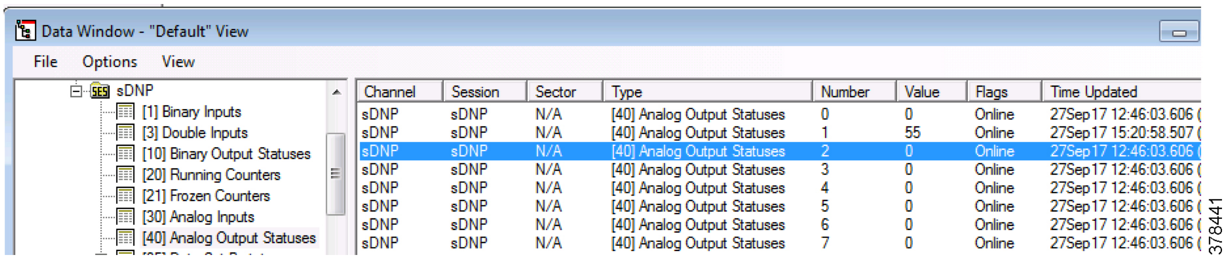
Drag a column header and drop it here to group by that column

| Point Type | # | Name | Value | Quality | Timestamp |
|---|---|---|---|---|---|
| [1] Discrete Input Registers | 3 | | On | N/A | 9/28/2017 11:52:06 AM |
| [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 |
| [0] Coils | 3 | | On | N/A | 9/28/2017 11:52:09 AM |
| [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

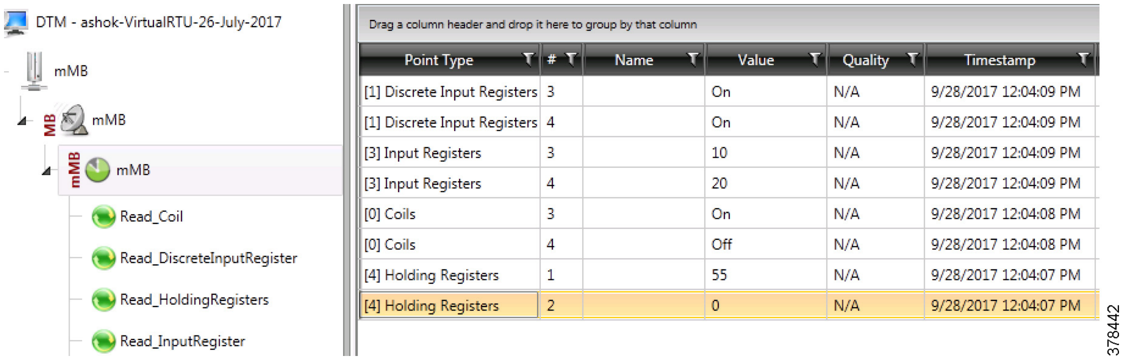
- sDNP
  - [1] Binary Inputs
  - [3] Double Inputs
  - [10] Binary Output Statuses
  - [20] Running Counters
  - [21] Frozen Counters
  - [30] Analog Inputs
  - [40] Analog Output Statuses

| Channel | Session | Sector | Type | Number | Value | Flags | Time Updated |
|---|---|---|---|---|---|---|---|
| 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 ( |
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 2 | 0 | Online | 27Sep17 12:46:03.606 ( |
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 3 | 0 | Online | 27Sep17 12:46:03.606 ( |
| 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 ( |
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 6 | 0 | Online | 27Sep17 12:46:03.606 ( |
| 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 Commands Register Present Value

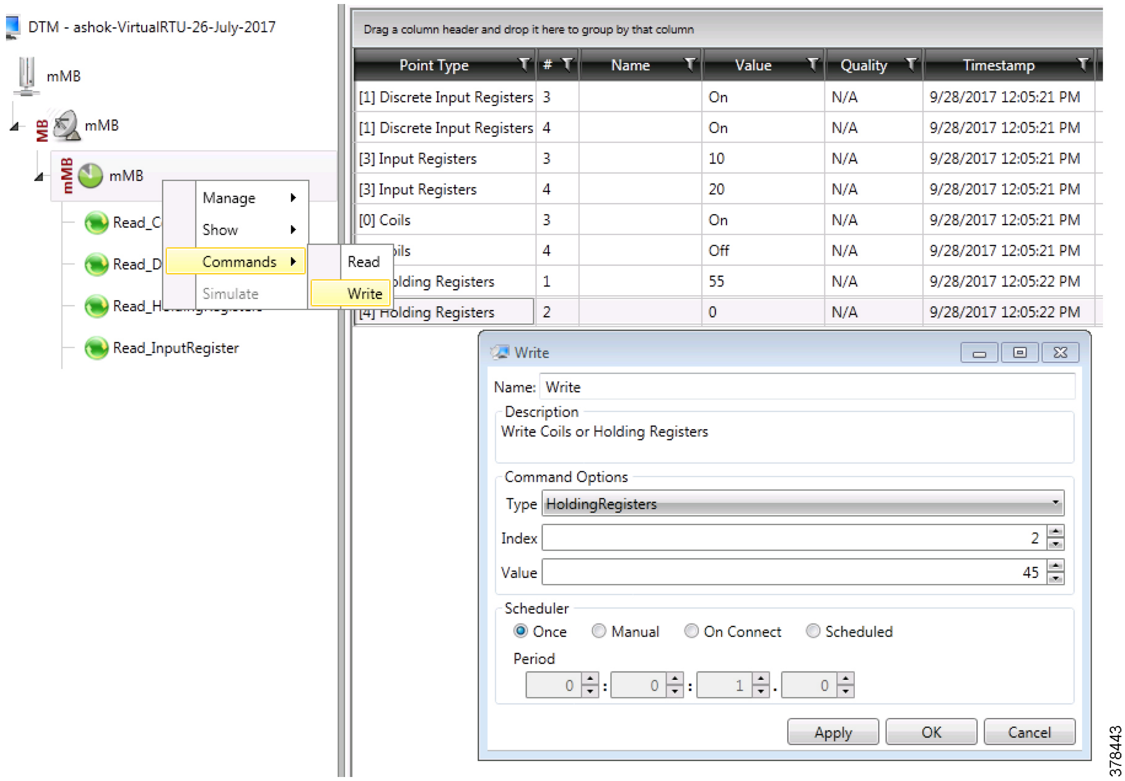

DTM - ashok-VirtualRTU-26-July-2017
mMB
MB
mMB
mMB
mMB
Read_Coil
Read_DiscreteInputRegister
Read_HoldingRegisters
Read_InputRegister
Drag a column header and drop it here to group by that column
378442

| Point Type | # | Name | Value | Quality | Timestamp |
|---|---|---|---|---|---|
| [1] Discrete Input Registers | 3 | | On | N/A | 9/28/2017 12:04:09 PM |
| [1] Discrete Input Registers | 4 | | On | N/A | 9/28/2017 12:04:09 PM |
| [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 |
| [0] Coils | 3 | | On | N/A | 9/28/2017 12:04:08 PM |
| [0] Coils | 4 | | Off | N/A | 9/28/2017 12:04:08 PM |
| [4] Holding Registers | 1 | | 55 | N/A | 9/28/2017 12:04:07 PM |
| [4] Holding Registers | 2 | | 0 | N/A | 9/28/2017 12:04:07 PM |

## Changing Normalized Commands Register 2 Value

See Figure 83:

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


DTM - ashok-VirtualRTU-26-July-2017
mMB
MB
mMB
mMB
mMB
Read_C
Read_D
Read_H
Read_InputRegister
Manage
Show
Commands
Simulate
Read
Write
Drag a column header and drop it here to group by that column
378443

| Point Type | # | Name | Value | Quality | Timestamp |
|---|---|---|---|---|---|
| [1] Discrete Input Registers | 3 | | On | N/A | 9/28/2017 12:05:21 PM |
| [1] Discrete Input Registers | 4 | | On | N/A | 9/28/2017 12:05:21 PM |
| [3] Input Registers | 3 | | 10 | N/A | 9/28/2017 12:05:21 PM |
| [3] Input Registers | 4 | | 20 | N/A | 9/28/2017 12:05:21 PM |
| [0] Coils | 3 | | On | N/A | 9/28/2017 12:05:21 PM |
| ils | 4 | | Off | N/A | 9/28/2017 12:05:21 PM |
| lding Registers | 1 | | 55 | N/A | 9/28/2017 12:05:22 PM |
| [4] Holding Registers | 2 | | 0 | N/A | 9/28/2017 12:05:22 PM |

Write

Name: Write

Description
Write Coils or Holding Registers

Command Options
Type HoldingRegisters
Index 2
Value 45

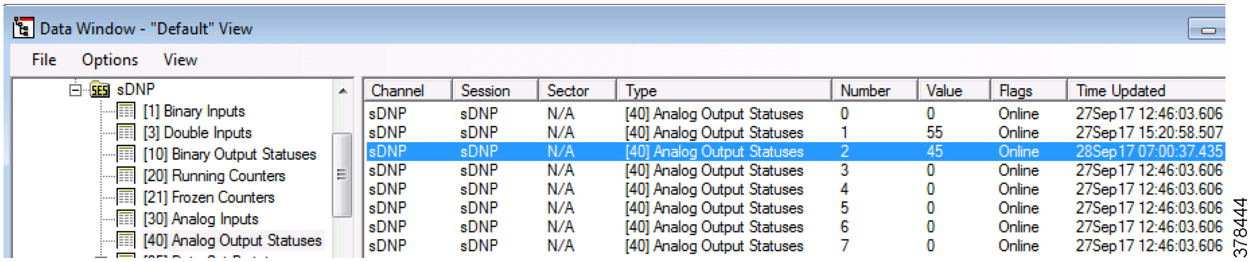
Scheduler
● Once ○ Manual ○ On Connect ○ Scheduled
Period 0 : 0 : 1 . 0

Apply OK Cancel

## Changes Reflecting in Southbound Binary Output Statuses Register 2

See Figure 84:

**Figure 84 Changes Reflected at Southbound Output Register**

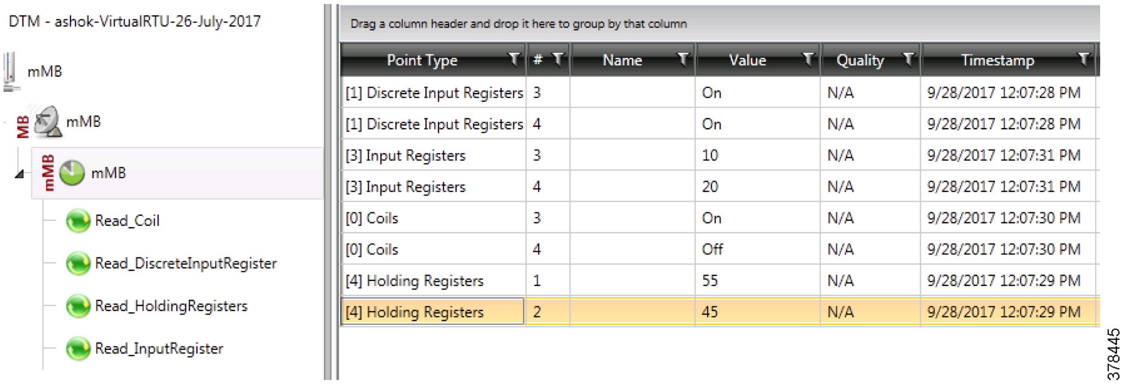


| Channel | Session | Sector | Type | Number | Value | Flags | Time Updated |
|---|---|---|---|---|---|---|---|
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 0 | 0 | Online | 27Sep17 12:46:03.606 |
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 1 | 55 | Online | 27Sep17 15:20:58.507 |
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 2 | 45 | Online | 28Sep17 07:00:37.435 |
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 3 | 0 | Online | 27Sep17 12:46:03.606 |
| 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 |
| sDNP | sDNP | N/A | [40] Analog Output Statuses | 6 | 0 | Online | 27Sep17 12:46:03.606 |
| 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
mMB
MB
mMB
mMB
mMB
Read_Coil
Read_DiscreteInputRegister
Read_HoldingRegisters
Read_InputRegister
Drag a column header and drop it here to group by that column
378445

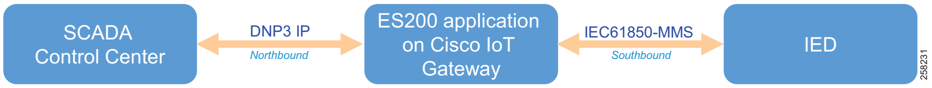
| Point Type | # | Name | Value | Quality | Timestamp |
|---|---|---|---|---|---|
| [1] Discrete Input Registers | 3 | | On | N/A | 9/28/2017 12:07:28 PM |
| [1] Discrete Input Registers | 4 | | On | N/A | 9/28/2017 12:07:28 PM |
| [3] Input Registers | 3 | | 10 | N/A | 9/28/2017 12:07:31 PM |
| [3] Input Registers | 4 | | 20 | N/A | 9/28/2017 12:07:31 PM |
| [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 |
| [4] Holding Registers | 1 | | 55 | N/A | 9/28/2017 12:07:29 PM |
| [4] Holding Registers | 2 | | 45 | N/A | 9/28/2017 12:07:29 PM |

# 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**

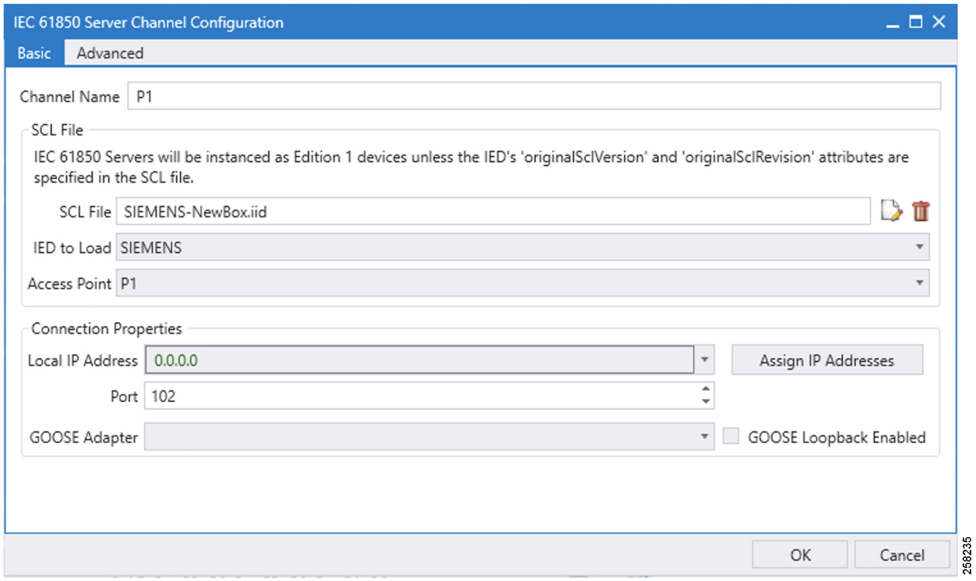


## Southbound IEC 61850-MMS TMW Configuration

### 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.

**Figure 87 IEC 61850-MMS Channel Configuration**



Channel Name P1

SCL File

IEC 61850 Servers will be instanced as Edition 1 devices unless the IED's 'originalSclVersion' and 'originalSclRevision' attributes are specified in the SCL file.

SCL File SIEMENS-NewBox.iid

IED to Load SIEMENS

Access Point P1

Connection Properties

Local IP Address 0.0.0.0

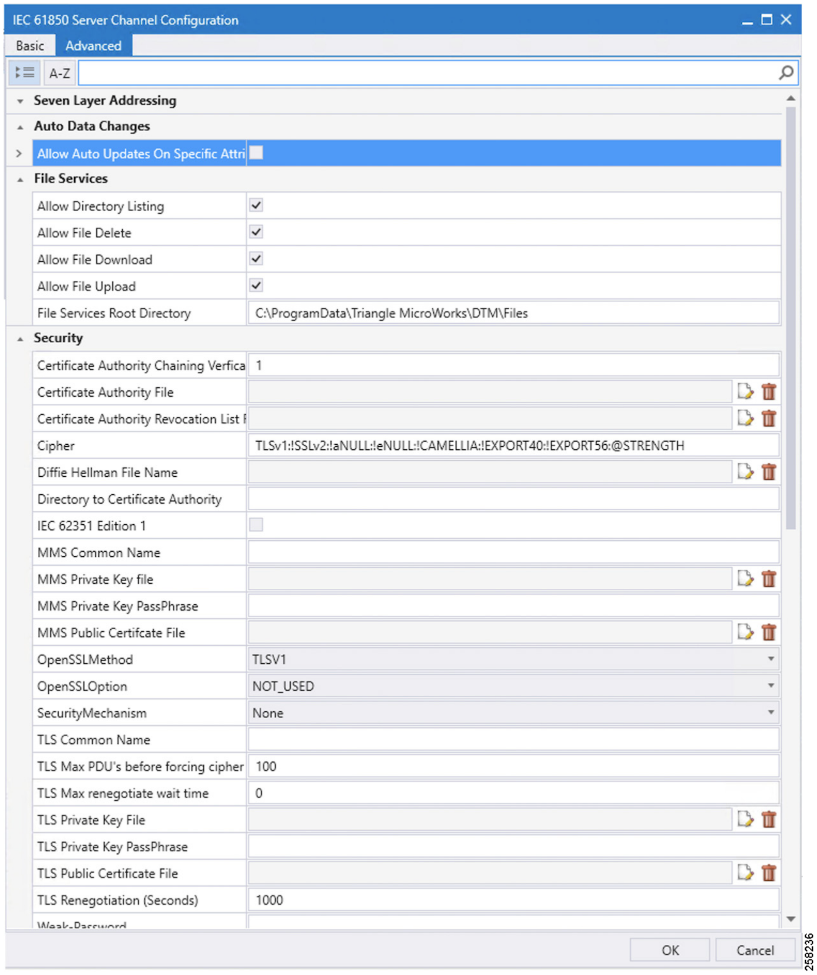
Port 102

GOOSE Adapter

□ GOOSE Loopback Enabled

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



Seven Layer Addressing

Auto Data Changes

| | |
|---|---|
| Allow Auto Updates On Specific Attri | □ |

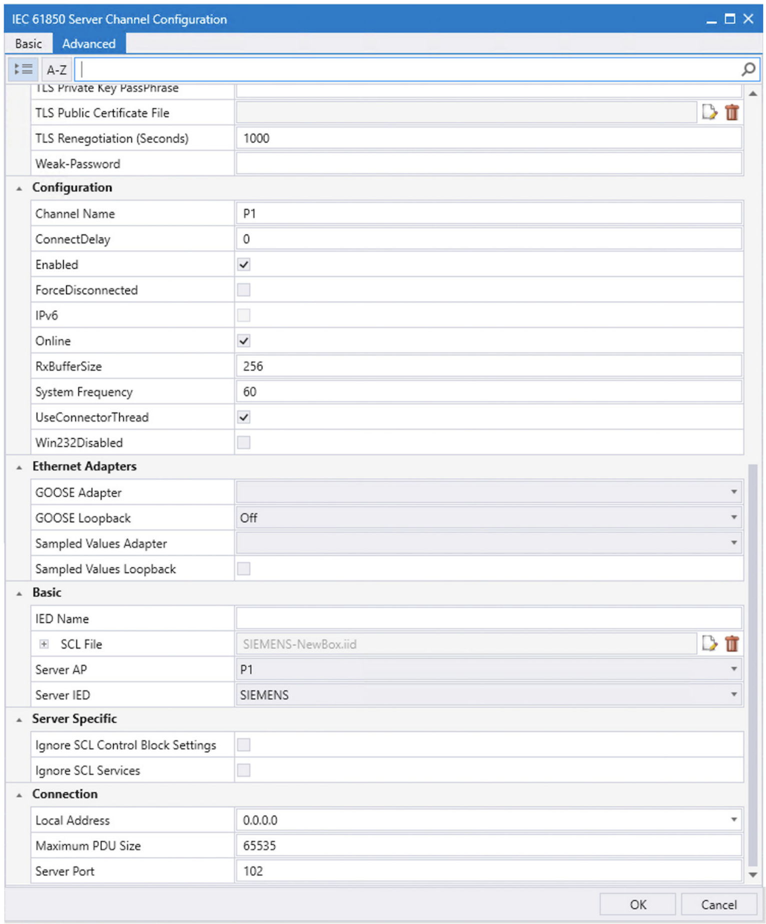
File Services

| | |
|---|---|
| Allow Directory Listing | ☑ |
| Allow File Delete | ☑ |
| Allow File Download | ☑ |
| Allow File Upload | ☑ |
| File Services Root Directory | C:\ProgramData\Triangle MicroWorks\DTM\Files |

Security

| | |
|---|---|
| Certificate Authority Chaining Verfica | 1 |
| Certificate Authority File | |
| Certificate Authority Revocation List F | |
| Cipher | TLSv1:!SSLv2:!aNULL:!eNULL:!CAMELLIA:!EXPORT40:!EXPORT56:@STRENGTH |
| Diffie Hellman File Name | |
| Directory to Certificate Authority | |
| IEC 62351 Edition 1 | □ |
| MMS Common Name | |
| MMS Private Key file | |
| MMS Private Key PassPhrase | |
| MMS Public Certifcate File | |
| 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 | |
| TLS Private Key PassPhrase | |
| TLS Public Certificate File | |
| TLS Renegotiation (Seconds) | 1000 |
| Weak-Password | |

### Figure 89 IEC 61850 Channel Configuration



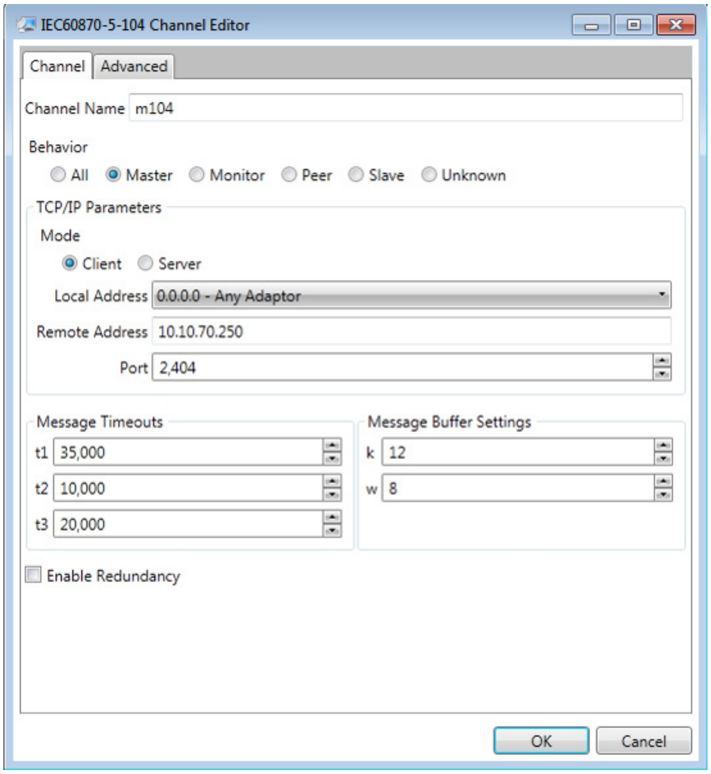
| | |
|---|---|
| TLS Private Key PassPhrase | |
| TLS Public Certificate File | |
| TLS Renegotiation (Seconds) | 1000 |
| Weak-Password | |
| **Configuration** | |
| Channel Name | P1 |
| ConnectDelay | 0 |
| Enabled | ☑ |
| ForceDisconnected | □ |
| IPv6 | □ |
| Online | ☑ |
| RxBufferSize | 256 |
| System Frequency | 60 |
| UseConnectorThread | ☑ |
| Win232Disabled | □ |
| **Ethernet Adapters** | |
| GOOSE Adapter | |
| GOOSE Loopback | Off |
| Sampled Values Adapter | |
| Sampled Values Loopback | □ |
| **Basic** | |
| IED Name | |
| SCL File | SIEMENS-NewBox.iid |
| 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 |

# 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**



IEC60870-5-104 Channel Editor

Channel | Advanced

Channel Name: m104

Behavior: ○ All ● Master ○ Monitor ○ Peer ○ Slave ○ Unknown

TCP/IP Parameters

Mode: ● Client ○ Server

Local Address: 0.0.0.0 - Any Adaptor

Remote Address: 10.10.70.250

Port: 2,404

Message Timeouts

t1: 35,000

t2: 10,000

t3: 20,000

Message Buffer Settings

k: 12

w: 8

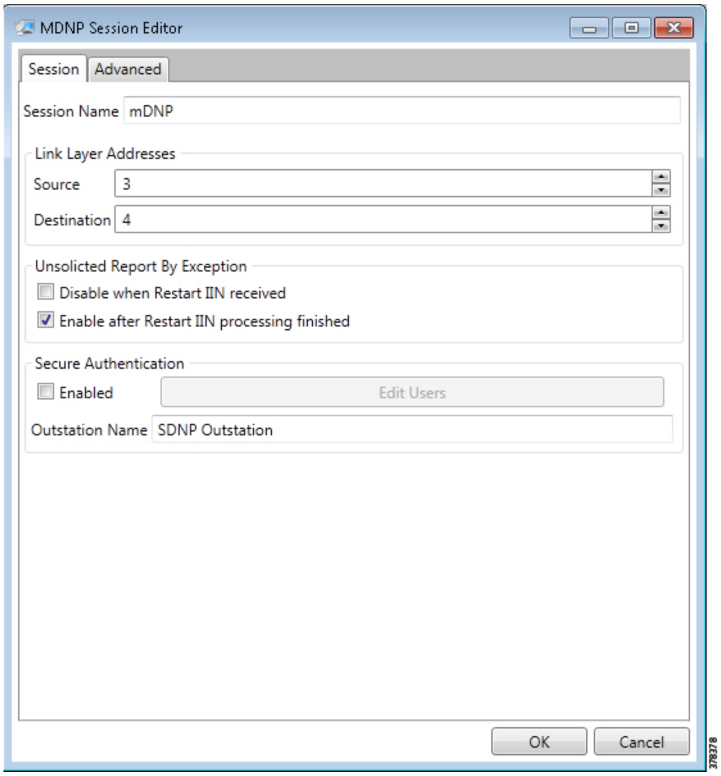
□ Enable Redundancy

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 Editor

Session | Advanced

Session Name: mDNP

Link Layer Addresses

Source: 3

Destination: 4

Unsolicted Report By Exception

□ Disable when Restart IIN received

☑ Enable after Restart IIN processing finished

Secure Authentication

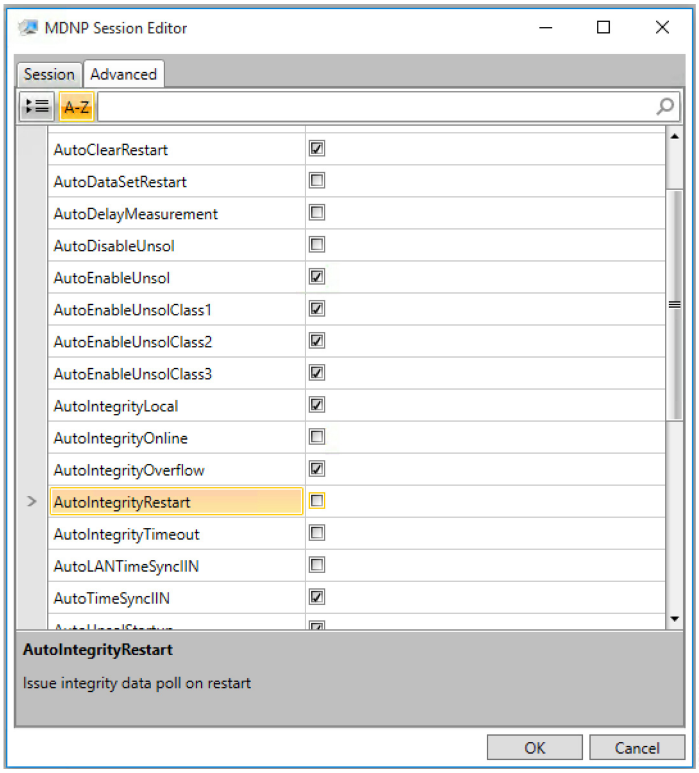
□ Enabled

Outstation Name: SDNP Outstation

## DNP3 IP Advanced Settings

AutoTimeSyncIIN 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:

**Figure 92 DNP3 Advance IP Session Configuration**



| | |
|---|---|
| AutoClearRestart | ☑ |
| AutoDataSetRestart | ☐ |
| AutoDelayMeasurement | ☐ |
| AutoDisableUnsol | ☐ |
| AutoEnableUnsol | ☑ |
| AutoEnableUnsolClass1 | ☑ |
| AutoEnableUnsolClass2 | ☑ |
| AutoEnableUnsolClass3 | ☑ |
| AutoIntegrityLocal | ☑ |
| AutoIntegrityOnline | ☐ |
| AutoIntegrityOverflow | ☑ |
| AutoIntegrityRestart | ☐ |
| AutoIntegrityTimeout | ☐ |
| AutoLANTimeSyncIIN | ☐ |
| AutoTimeSyncIIN | ☑ |
| AutoUnsolStartup | ☑ |

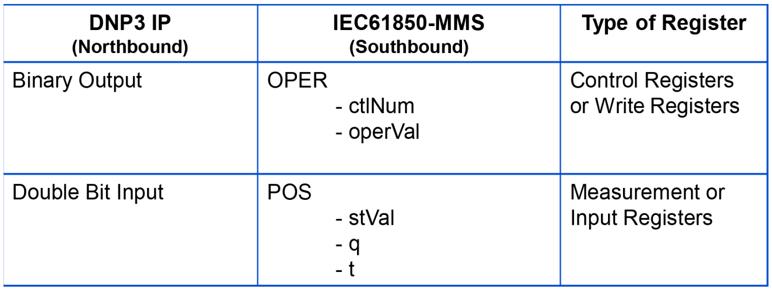
**AutoIntegrityRestart**

Issue integrity data poll on restart

## 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:

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



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

**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 94 Integrity Data Poll**

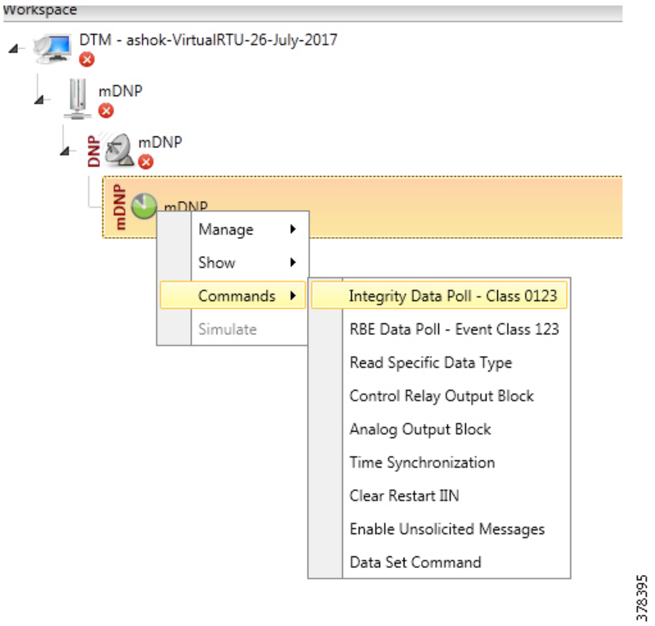
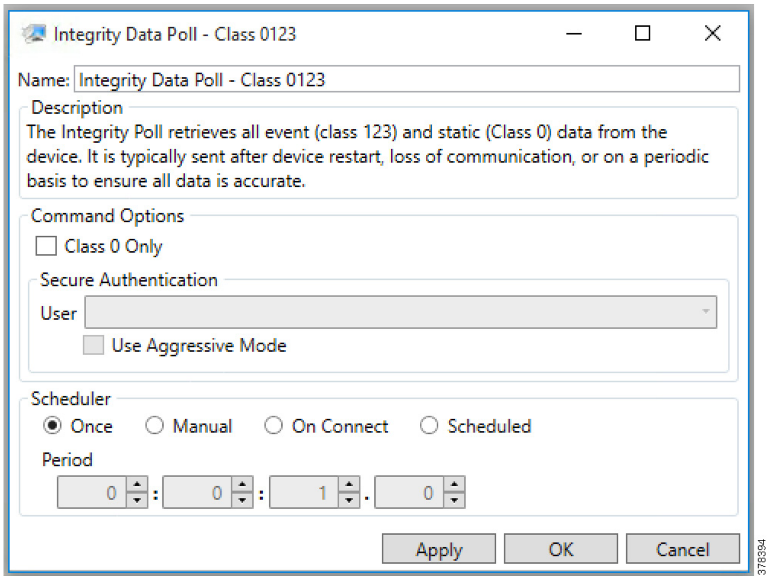


**Figure 95 Integrity Data Poll Class0123**



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 after device restart, loss of communication, or on a periodic basis to ensure all data is accurate.

Command Options

□ Class 0 Only

Secure Authentication

User

□ Use Aggressive Mode

Scheduler

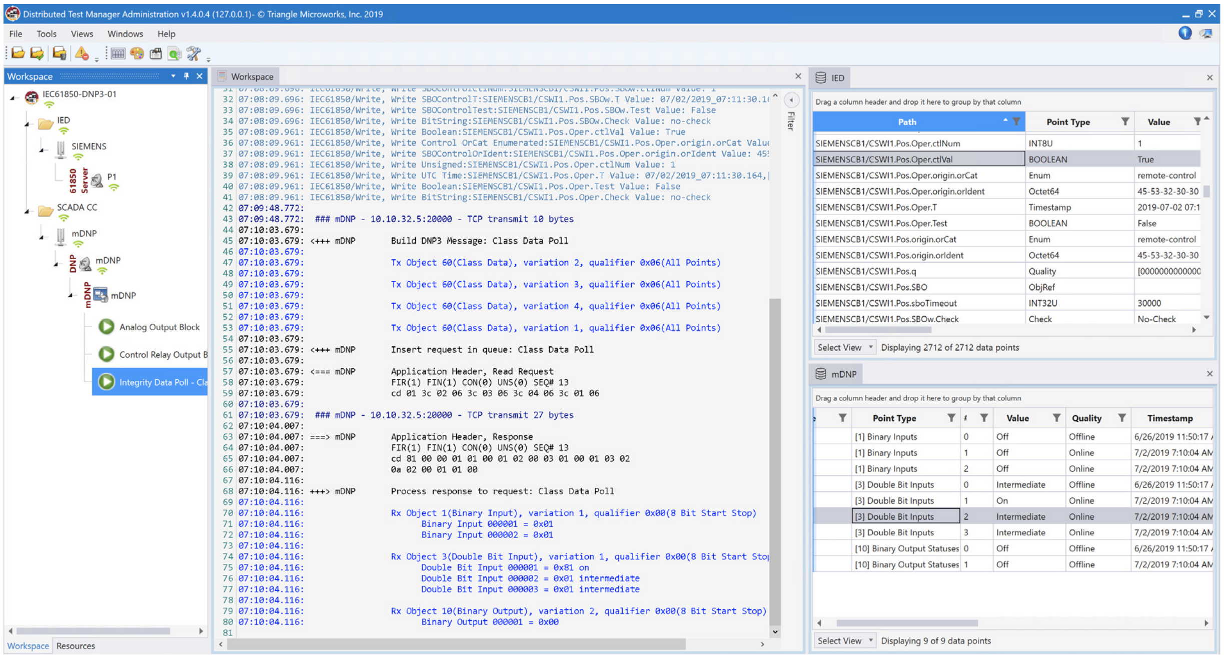
● Once ○ Manual ○ On Connect ○ Scheduled

Period

0 : 0 : 1 . 0

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.

**Figure 96 DNP3 IP Point List**



```
07:08:09.696: IEC61850/Write, Write SBOControlT:SIEMENSCB1/CSWI1.Pos.SBOw.T Value: 07/02/2019_07:11:30.1
07:08:09.696: IEC61850/Write, Write SBOControlTest:SIEMENSCB1/CSWI1.Pos.SBOw.Test Value: False
07:08:09.696: IEC61850/Write, Write BitString:SIEMENSCB1/CSWI1.Pos.SBOw.Check Value: no-check
07:08:09.961: IEC61850/Write, Write Boolean:SIEMENSCB1/CSWI1.Pos.Oper.ctlVal Value: True
07:08:09.961: IEC61850/Write, Write Control OrCat Enumerated:SIEMENSCB1/CSWI1.Pos.Oper.origin.orCat Value
07:08:09.961: IEC61850/Write, Write SBOControlOrIdent:SIEMENSCB1/CSWI1.Pos.Oper.origin.orIdent Value: 45
07:08:09.961: IEC61850/Write, Write Unsigned:SIEMENSCB1/CSWI1.Pos.Oper.ctlNum Value: 1
07:08:09.961: IEC61850/Write, Write UTC Time:SIEMENSCB1/CSWI1.Pos.Oper.T Value: 07/02/2019_07:11:30.164,
07:08:09.961: IEC61850/Write, Write Boolean:SIEMENSCB1/CSWI1.Pos.Oper.Test Value: False
07:08:09.961: IEC61850/Write, Write BitString:SIEMENSCB1/CSWI1.Pos.Oper.Check Value: no-check
07:09:48.772:
07:09:48.772:  ### mDNP - 10.10.32.5:20000 - TCP transmit 10 bytes
07:10:03.679:
07:10:03.679: <+++ mDNP       Build DNP3 Message: Class Data Poll
07:10:03.679:
07:10:03.679:                 Tx Object 60(Class Data), variation 2, qualifier 0x06(All Points)
07:10:03.679:
07:10:03.679:                 Tx Object 60(Class Data), variation 3, qualifier 0x06(All Points)
07:10:03.679:
07:10:03.679:                 Tx Object 60(Class Data), variation 4, qualifier 0x06(All Points)
07:10:03.679:
07:10:03.679:                 Tx Object 60(Class Data), variation 1, qualifier 0x06(All Points)
07:10:03.679:
07:10:03.679: <+++ mDNP       Insert request in queue: Class Data Poll
07:10:03.679:
07:10:03.679: <=== mDNP       Application Header, Read Request
07:10:03.679:                 FIR(1) FIN(1) CON(0) UNS(0) SEQ# 13
07:10:03.679:                 cd 01 3c 02 06 3c 03 06 3c 04 06 3c 01 06
07:10:03.679:
07:10:03.679:  ### mDNP - 10.10.32.5:20000 - TCP transmit 27 bytes
07:10:04.007:
07:10:04.007: ===> mDNP       Application Header, Response
07:10:04.007:                 FIR(1) FIN(1) CON(0) UNS(0) SEQ# 13
07:10:04.007:                 cd 81 00 00 01 01 00 01 02 00 03 01 00 01 03 02
07:10:04.007:                 0a 02 00 01 01 00
07:10:04.116:
07:10:04.116: +++> mDNP       Process response to request: Class Data Poll
07:10:04.116:
07:10:04.116:                 Rx Object 1(Binary Input), variation 1, qualifier 0x00(8 Bit Start Stop)
07:10:04.116:                     Binary Input 000001 = 0x01
07:10:04.116:                     Binary Input 000002 = 0x01
07:10:04.116:
07:10:04.116:                 Rx Object 3(Double Bit Input), variation 1, qualifier 0x00(8 Bit Start Stop
07:10:04.116:                     Double Bit Input 000001 = 0x81 on
07:10:04.116:                     Double Bit Input 000002 = 0x01 intermediate
07:10:04.116:                     Double Bit Input 000003 = 0x01 intermediate
07:10:04.116:
07:10:04.116:                 Rx Object 10(Binary Output), variation 2, qualifier 0x00(8 Bit Start Stop)
07:10:04.116:                     Binary Output 000001 = 0x00
```

IED

Drag a column header and drop it here to group by that column

| Path | Point Type | Value |
|---|---|---|
| SIEMENSCB1/CSWI1.Pos.Oper.ctlNum | INT8U | 1 |
| SIEMENSCB1/CSWI1.Pos.Oper.ctlVal | BOOLEAN | True |
| SIEMENSCB1/CSWI1.Pos.Oper.origin.orCat | Enum | remote-control |
| SIEMENSCB1/CSWI1.Pos.Oper.origin.orIdent | Octet64 | 45-53-32-30-30 |
| SIEMENSCB1/CSWI1.Pos.Oper.T | Timestamp | 2019-07-02 07:1 |
| SIEMENSCB1/CSWI1.Pos.Oper.Test | BOOLEAN | False |
| SIEMENSCB1/CSWI1.Pos.origin.orCat | Enum | remote-control |
| SIEMENSCB1/CSWI1.Pos.origin.orIdent | Octet64 | 45-53-32-30-30 |
| SIEMENSCB1/CSWI1.Pos.q | Quality | [000000000000 |
| SIEMENSCB1/CSWI1.Pos.SBO | ObjRef | |
| SIEMENSCB1/CSWI1.Pos.sboTimeout | INT32U | 30000 |
| SIEMENSCB1/CSWI1.Pos.SBOw.Check | Check | No-Check |

Select View ▾ Displaying 2712 of 2712 data points

mDNP

Drag a column header and drop it here to group by that column

| Point Type | # | Value | Quality | Timestamp |
|---|---|---|---|---|
| [1] Binary Inputs | 0 | Off | Offline | 6/26/2019 11:50:17 / |
| [1] Binary Inputs | 1 | Off | Online | 7/2/2019 7:10:04 AM |
| [1] Binary Inputs | 2 | Off | Online | 7/2/2019 7:10:04 AM |
| [3] Double Bit Inputs | 0 | Intermediate | Offline | 6/26/2019 11:50:17 / |
| [3] Double Bit Inputs | 1 | On | Online | 7/2/2019 7:10:04 AM |
| [3] Double Bit Inputs | 2 | Intermediate | Online | 7/2/2019 7:10:04 AM |
| [3] Double Bit Inputs | 3 | Intermediate | Online | 7/2/2019 7:10:04 AM |
| [10] Binary Output Statuses | 0 | Off | Offline | 6/26/2019 11:50:17 / |
| [10] Binary Output Statuses | 1 | Off | Offline | 7/2/2019 7:10:04 AM |

Select View ▾ Displaying 9 of 9 data points

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.

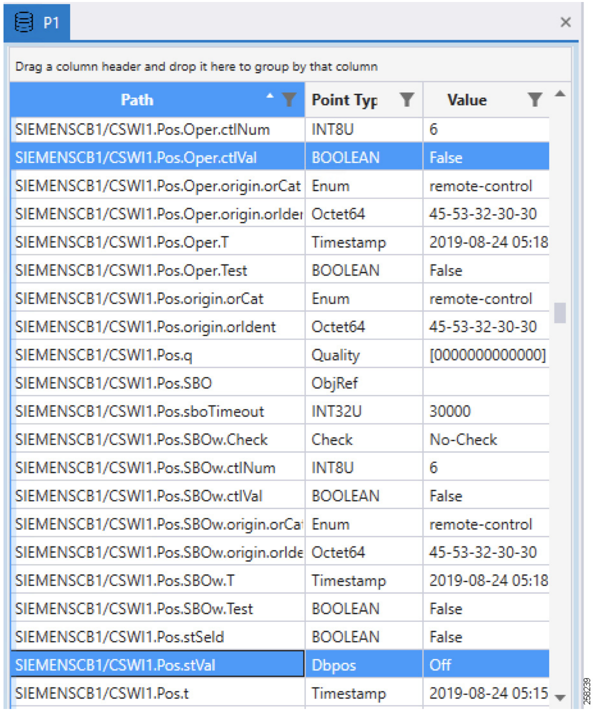
For the purposes of this document, we just discussed Double Bit Input register values for the Integrity poll.

## 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:

**Figure 97 IEC 61850 Southbound Point List Status**

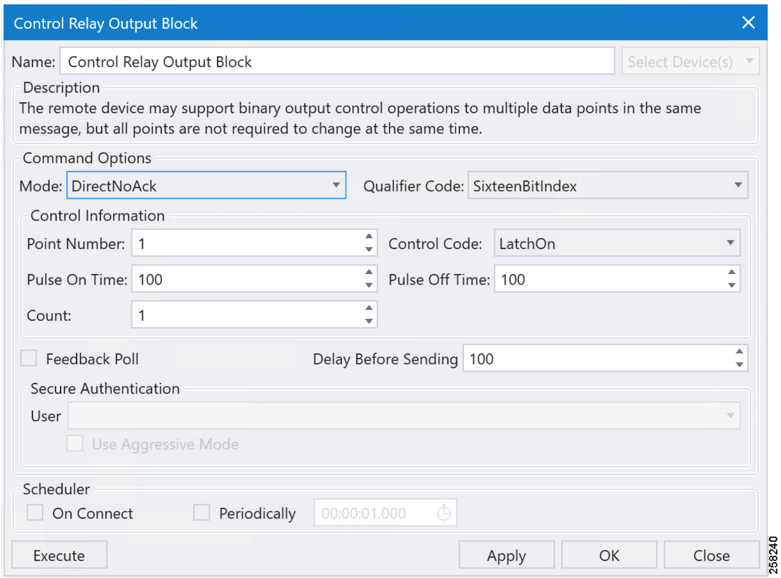


P1
Drag a column header and drop it here to group by that column
258239

| Path | Point Typ | Value |
|---|---|---|
| SIEMENSCB1/CSWI1.Pos.Oper.ctlNum | INT8U | 6 |
| SIEMENSCB1/CSWI1.Pos.Oper.ctlVal | BOOLEAN | False |
| SIEMENSCB1/CSWI1.Pos.Oper.origin.orCat | Enum | remote-control |
| SIEMENSCB1/CSWI1.Pos.Oper.origin.orIder | Octet64 | 45-53-32-30-30 |
| SIEMENSCB1/CSWI1.Pos.Oper.T | Timestamp | 2019-08-24 05:18 |
| SIEMENSCB1/CSWI1.Pos.Oper.Test | BOOLEAN | False |
| SIEMENSCB1/CSWI1.Pos.origin.orCat | Enum | remote-control |
| SIEMENSCB1/CSWI1.Pos.origin.orIdent | Octet64 | 45-53-32-30-30 |
| SIEMENSCB1/CSWI1.Pos.q | Quality | [0000000000000] |
| SIEMENSCB1/CSWI1.Pos.SBO | ObjRef | |
| SIEMENSCB1/CSWI1.Pos.sboTimeout | INT32U | 30000 |
| SIEMENSCB1/CSWI1.Pos.SBOw.Check | Check | No-Check |
| SIEMENSCB1/CSWI1.Pos.SBOw.ctlNum | INT8U | 6 |
| SIEMENSCB1/CSWI1.Pos.SBOw.ctlVal | BOOLEAN | False |
| SIEMENSCB1/CSWI1.Pos.SBOw.origin.orCat | Enum | remote-control |
| SIEMENSCB1/CSWI1.Pos.SBOw.origin.orIde | Octet64 | 45-53-32-30-30 |
| SIEMENSCB1/CSWI1.Pos.SBOw.T | Timestamp | 2019-08-24 05:18 |
| SIEMENSCB1/CSWI1.Pos.SBOw.Test | BOOLEAN | False |
| SIEMENSCB1/CSWI1.Pos.stSeld | BOOLEAN | False |
| SIEMENSCB1/CSWI1.Pos.stVal | Dbpos | Off |
| SIEMENSCB1/CSWI1.Pos.t | Timestamp | 2019-08-24 05:15 |

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 CROB Control Command



Control Relay Output Block

Name: Control Relay Output Block

Description
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.

Command Options

Mode: DirectNoAck

Qualifier Code: SixteenBitIndex

Control Information

Point Number: 1

Control Code: LatchOn

Pulse On Time: 100

Pulse Off Time: 100

Count: 1

□ Feedback Poll

Delay Before Sending 100

Secure Authentication

User

□ Use Aggressive Mode

Scheduler

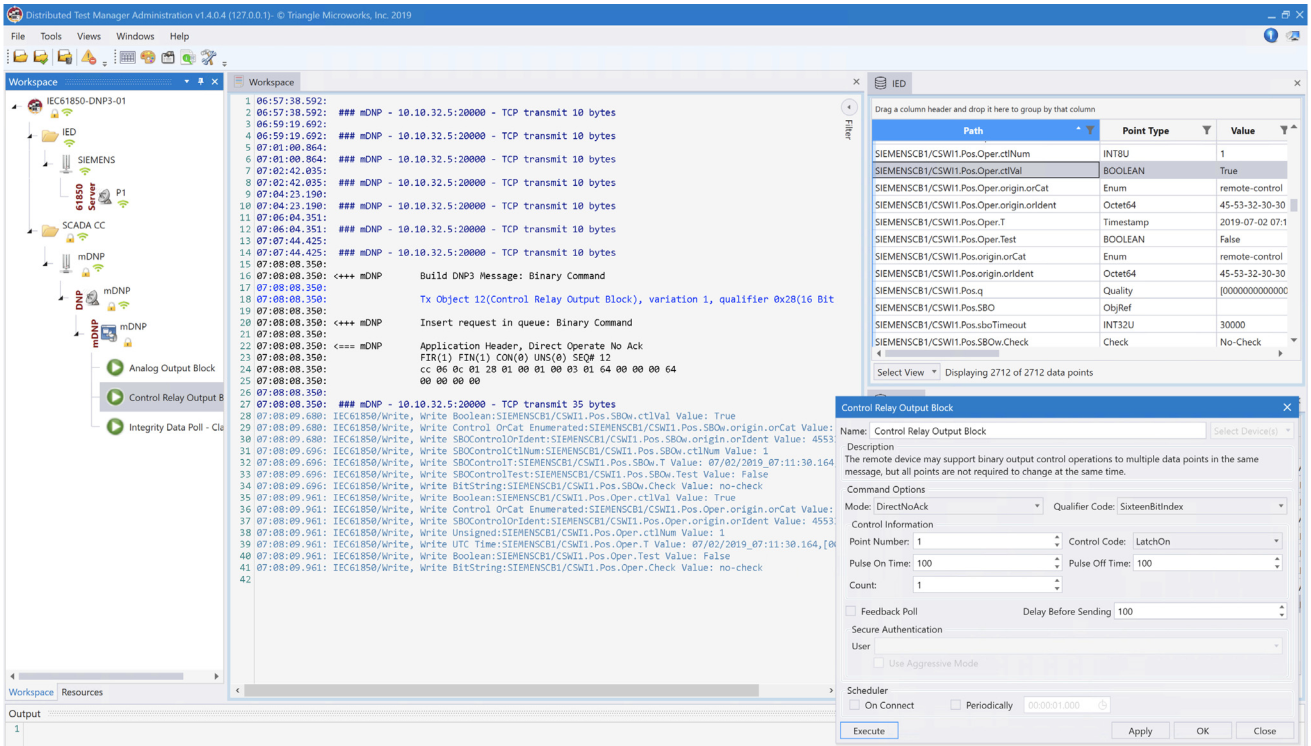
□ On Connect

□ Periodically 00:00:01.000

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.

### Figure 99 IEC 61850 Southbound Register Value Changed to True



```
06:57:38.592:
06:57:38.592:  ### mDNP - 10.10.32.5:20000 - TCP transmit 10 bytes
06:59:19.692:
06:59:19.692:  ### mDNP - 10.10.32.5:20000 - TCP transmit 10 bytes
07:01:00.864:
07:01:00.864:  ### mDNP - 10.10.32.5:20000 - TCP transmit 10 bytes
07:02:42.035:
07:02:42.035:  ### mDNP - 10.10.32.5:20000 - TCP transmit 10 bytes
07:04:23.190:
07:04:23.190:  ### mDNP - 10.10.32.5:20000 - TCP transmit 10 bytes
07:06:04.351:
07:06:04.351:  ### mDNP - 10.10.32.5:20000 - TCP transmit 10 bytes
07:07:44.425:
07:07:44.425:  ### mDNP - 10.10.32.5:20000 - TCP transmit 10 bytes
07:08:08.350:
07:08:08.350: <+++ mDNP       Build DNP3 Message: Binary Command
07:08:08.350:
07:08:08.350:                 Tx Object 12(Control Relay Output Block), variation 1, qualifier 0x28(16 Bit
07:08:08.350:
07:08:08.350: <+++ mDNP       Insert request in queue: Binary Command
07:08:08.350:
07:08:08.350: <=== mDNP       Application Header, Direct Operate No Ack
07:08:08.350:                 FIR(1) FIN(1) CON(0) UNS(0) SEQ# 12
07:08:08.350:                 cc 06 0c 01 28 01 00 01 00 03 01 64 00 00 00 64
07:08:08.350:                 00 00 00 00
07:08:08.350:
07:08:08.350:  ### mDNP - 10.10.32.5:20000 - TCP transmit 35 bytes
07:08:09.680: IEC61850/Write, Write Boolean:SIEMENSCB1/CSWI1.Pos.SBOw.ctlVal Value: True
07:08:09.680: IEC61850/Write, Write Control OrCat Enumerated:SIEMENSCB1/CSWI1.Pos.SBOw.origin.orCat Value:
07:08:09.680: IEC61850/Write, Write SBOControlOrIdent:SIEMENSCB1/CSWI1.Pos.SBOw.origin.orIdent Value: 4553
07:08:09.696: IEC61850/Write, Write SBOControlCtlNum:SIEMENSCB1/CSWI1.Pos.SBOw.ctlNum Value: 1
07:08:09.696: IEC61850/Write, Write SBOControlT:SIEMENSCB1/CSWI1.Pos.SBOw.T Value: 07/02/2019_07:11:30.164
07:08:09.696: IEC61850/Write, Write SBOControlTest:SIEMENSCB1/CSWI1.Pos.SBOw.Test Value: False
07:08:09.696: IEC61850/Write, Write BitString:SIEMENSCB1/CSWI1.Pos.SBOw.Check Value: no-check
07:08:09.961: IEC61850/Write, Write Boolean:SIEMENSCB1/CSWI1.Pos.Oper.ctlVal Value: True
07:08:09.961: IEC61850/Write, Write Control OrCat Enumerated:SIEMENSCB1/CSWI1.Pos.Oper.origin.orCat Value:
07:08:09.961: IEC61850/Write, Write SBOControlOrIdent:SIEMENSCB1/CSWI1.Pos.Oper.origin.orIdent Value: 4553
07:08:09.961: IEC61850/Write, Write Unsigned:SIEMENSCB1/CSWI1.Pos.Oper.ctlNum Value: 1
07:08:09.961: IEC61850/Write, Write UTC Time:SIEMENSCB1/CSWI1.Pos.Oper.T Value: 07/02/2019_07:11:30.164,[0
07:08:09.961: IEC61850/Write, Write Boolean:SIEMENSCB1/CSWI1.Pos.Oper.Test Value: False
07:08:09.961: IEC61850/Write, Write BitString:SIEMENSCB1/CSWI1.Pos.Oper.Check Value: no-check
```

Drag a column header and drop it here to group by that column

| Path | Point Type | Value |
|---|---|---|
| SIEMENSCB1/CSWI1.Pos.Oper.ctlNum | INT8U | 1 |
| SIEMENSCB1/CSWI1.Pos.Oper.ctlVal | BOOLEAN | True |
| SIEMENSCB1/CSWI1.Pos.Oper.origin.orCat | Enum | remote-control |
| SIEMENSCB1/CSWI1.Pos.Oper.origin.orIdent | Octet64 | 45-53-32-30-30 |
| SIEMENSCB1/CSWI1.Pos.Oper.T | Timestamp | 2019-07-02 07:1 |
| SIEMENSCB1/CSWI1.Pos.Oper.Test | BOOLEAN | False |
| SIEMENSCB1/CSWI1.Pos.origin.orCat | Enum | remote-control |
| SIEMENSCB1/CSWI1.Pos.origin.orIdent | Octet64 | 45-53-32-30-30 |
| SIEMENSCB1/CSWI1.Pos.q | Quality | [0000000000000 |
| SIEMENSCB1/CSWI1.Pos.SBO | ObjRef | |
| SIEMENSCB1/CSWI1.Pos.sboTimeout | INT32U | 30000 |
| SIEMENSCB1/CSWI1.Pos.SBOw.Check | Check | No-Check |

Select View ▾ Displaying 2712 of 2712 data points

Control Relay Output Block

Name: Control Relay Output Block    Select Device(s) ▾

Description
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.

Command Options
Mode: DirectNoAck    Qualifier Code: SixteenBitIndex

Control Information
Point Number: 1    Control Code: LatchOn
Pulse On Time: 100    Pulse Off Time: 100
Count: 1

□ Feedback Poll    Delay Before Sending 100

Secure Authentication
User
□ Use Aggressive Mode

Scheduler
□ On Connect    □ Periodically 00:00:01.000

Execute    Apply    OK    Close

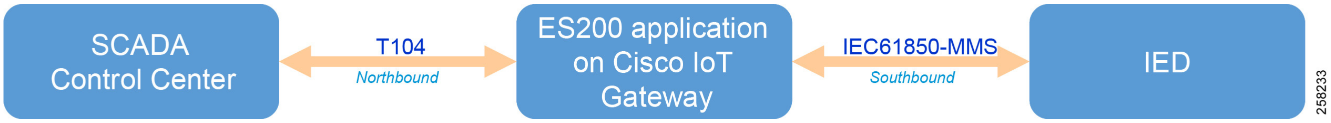
# IEC 61850-MMS (Southbound) to T104 (Northbound) Translation Use Case

## 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

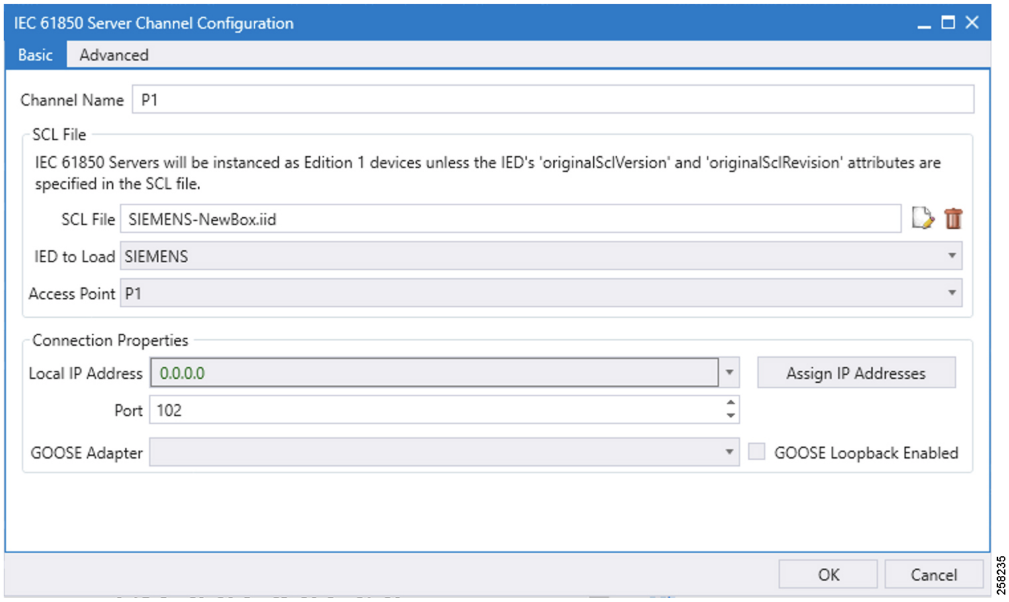


# Southbound IEC 61850-MMS TMW Configuration

## 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 Channel Configuration

Basic | Advanced

Channel Name: P1

SCL File

IEC 61850 Servers will be instanced as Edition 1 devices unless the IED's 'originalSclVersion' and 'originalSclRevision' attributes are specified in the SCL file.

SCL File: SIEMENS-NewBox.iid

IED to Load: SIEMENS

Access Point: P1

Connection Properties

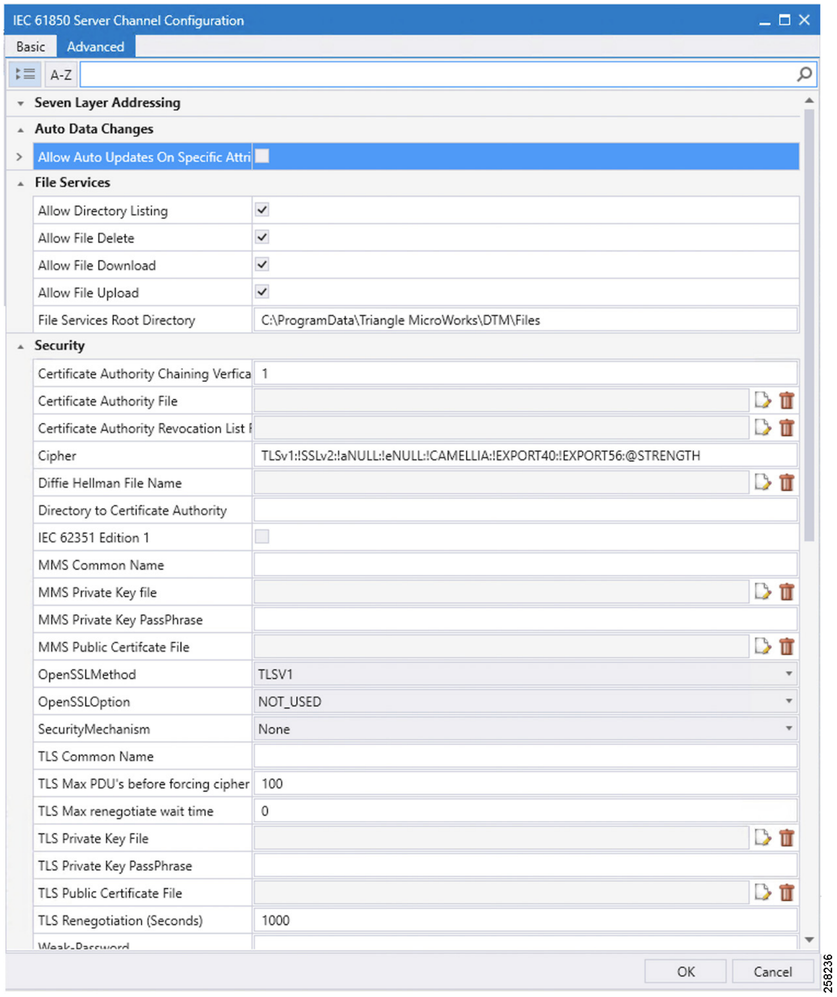
Local IP Address: 0.0.0.0

Port: 102

GOOSE Adapter:

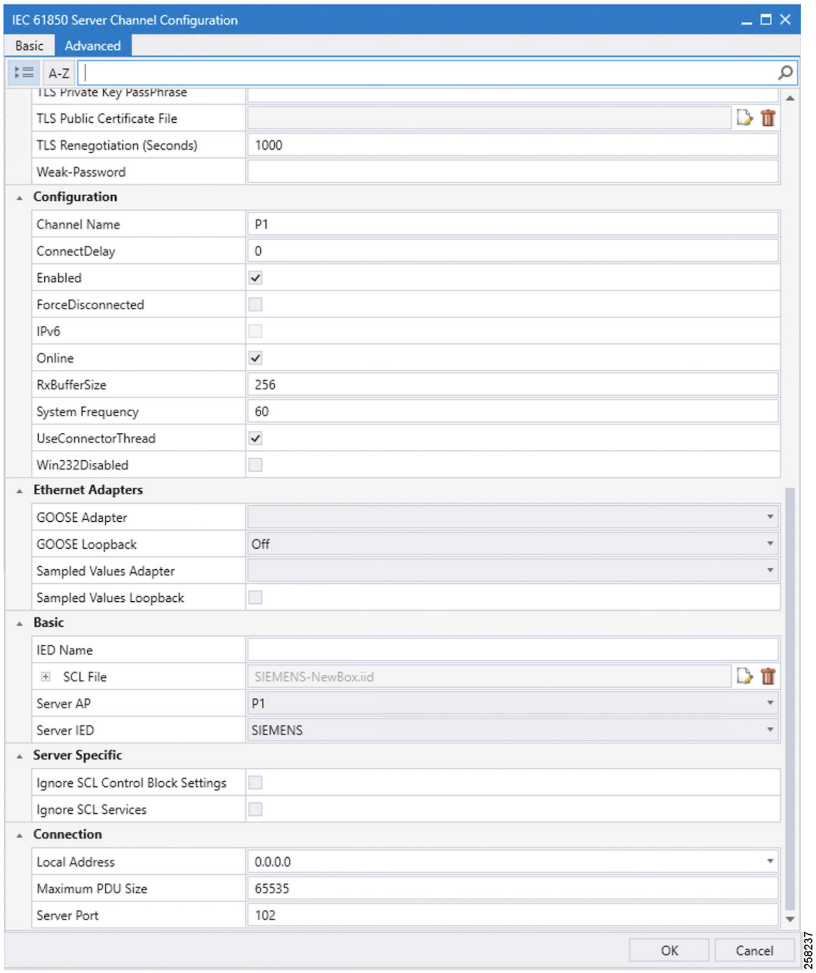
□ GOOSE Loopback Enabled

### Figure 102 IEC 61850 Advanced Channel Configuration



| | |
|---|---|
| **Seven Layer Addressing** | |
| **Auto Data Changes** | |
| Allow Auto Updates On Specific Attri | □ |
| **File Services** | |
| Allow Directory Listing | ☑ |
| Allow File Delete | ☑ |
| Allow File Download | ☑ |
| Allow File Upload | ☑ |
| File Services Root Directory | C:\ProgramData\Triangle MicroWorks\DTM\Files |
| **Security** | |
| Certificate Authority Chaining Verfica | 1 |
| Certificate Authority File | |
| Certificate Authority Revocation List F | |
| Cipher | TLSv1:!SSLv2:!aNULL:!eNULL:!CAMELLIA:!EXPORT40:!EXPORT56:@STRENGTH |
| Diffie Hellman File Name | |
| Directory to Certificate Authority | |
| IEC 62351 Edition 1 | □ |
| MMS Common Name | |
| MMS Private Key file | |
| MMS Private Key PassPhrase | |
| MMS Public Certifcate File | |
| 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 | |
| TLS Private Key PassPhrase | |
| TLS Public Certificate File | |
| TLS Renegotiation (Seconds) | 1000 |
| Weak-Password | |

**Figure 103 IEC 61850 Channel Configuration Advanced Continued**



IEC 61850 Server Channel Configuration

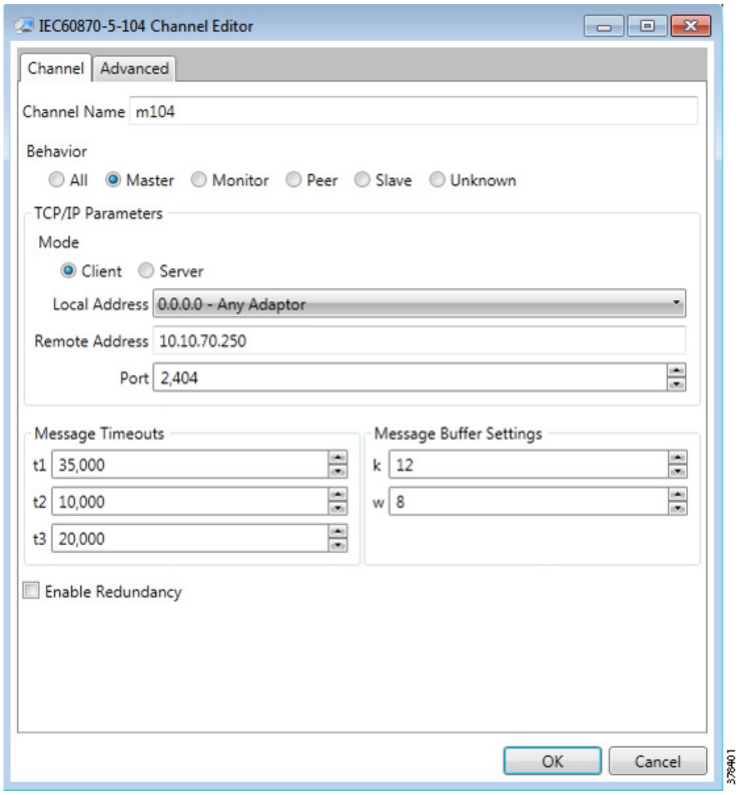
|  |  |
|---|---|
| TLS Private Key PassPhrase | |
| TLS Public Certificate File | |
| TLS Renegotiation (Seconds) | 1000 |
| Weak-Password | |
| **Configuration** | |
| Channel Name | P1 |
| ConnectDelay | 0 |
| Enabled | ☑ |
| ForceDisconnected | ☐ |
| IPv6 | ☐ |
| Online | ☑ |
| RxBufferSize | 256 |
| System Frequency | 60 |
| UseConnectorThread | ☑ |
| Win232Disabled | ☐ |
| **Ethernet Adapters** | |
| GOOSE Adapter | |
| GOOSE Loopback | Off |
| Sampled Values Adapter | |
| Sampled Values Loopback | ☐ |
| **Basic** | |
| IED Name | |
| SCL File | SIEMENS-NewBox.iid |
| 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 |

# 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**



IEC60870-5-104 Channel Editor

Channel | Advanced

Channel Name: m104

Behavior: ○ All ● Master ○ Monitor ○ Peer ○ Slave ○ Unknown

TCP/IP Parameters

Mode: ● Client ○ Server

Local Address: 0.0.0.0 - Any Adaptor

Remote Address: 10.10.70.250

Port: 2,404

Message Timeouts

t1: 35,000

t2: 10,000

t3: 20,000

Message Buffer Settings

k: 12

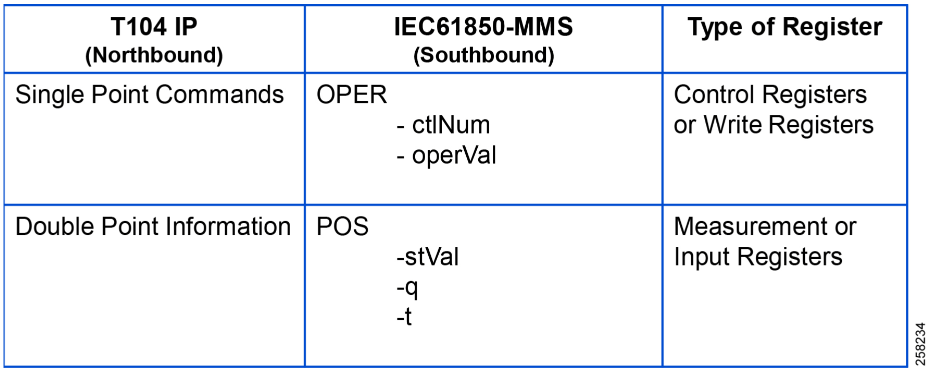
w: 8

□ Enable Redundancy

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

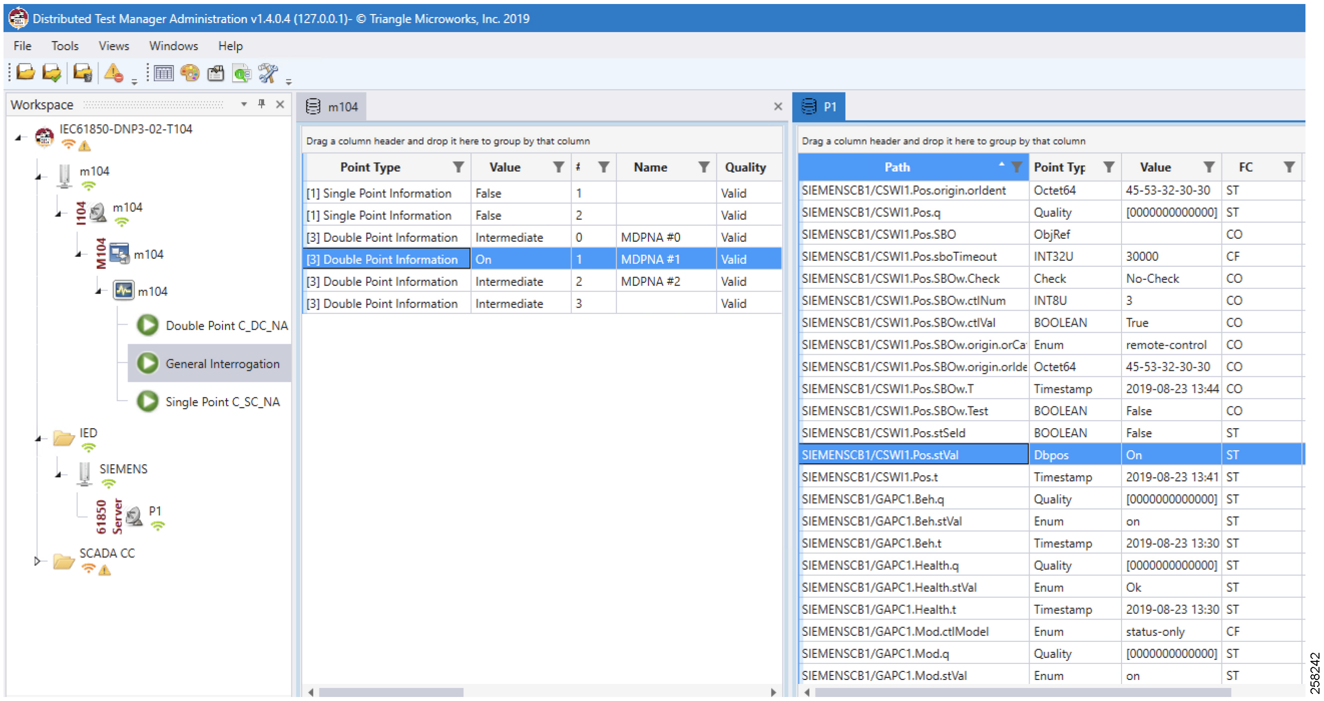
## Reading IEC 61850 Southbound Data from Northbound T104 Control Center

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



Drag a column header and drop it here to group by that column

| Point Type | Value | # | Name | Quality |
|---|---|---|---|---|
| [1] Single Point Information | False | 1 | | Valid |
| [1] Single Point Information | False | 2 | | Valid |
| [3] Double Point Information | Intermediate | 0 | MDPNA #0 | Valid |
| [3] Double Point Information | On | 1 | MDPNA #1 | Valid |
| [3] Double Point Information | Intermediate | 2 | MDPNA #2 | Valid |
| [3] Double Point Information | Intermediate | 3 | | Valid |

Drag a column header and drop it here to group by that column

| Path | Point Typ | Value | FC |
|---|---|---|---|
| SIEMENSCB1/CSWI1.Pos.origin.orIdent | Octet64 | 45-53-32-30-30 | ST |
| SIEMENSCB1/CSWI1.Pos.q | Quality | [0000000000000] | ST |
| SIEMENSCB1/CSWI1.Pos.SBO | ObjRef | | CO |
| SIEMENSCB1/CSWI1.Pos.sboTimeout | INT32U | 30000 | CF |
| SIEMENSCB1/CSWI1.Pos.SBOw.Check | Check | No-Check | CO |
| SIEMENSCB1/CSWI1.Pos.SBOw.ctlNum | INT8U | 3 | CO |
| SIEMENSCB1/CSWI1.Pos.SBOw.ctlVal | BOOLEAN | True | CO |
| SIEMENSCB1/CSWI1.Pos.SBOw.origin.orCa | Enum | remote-control | CO |
| SIEMENSCB1/CSWI1.Pos.SBOw.origin.orIde | Octet64 | 45-53-32-30-30 | CO |
| SIEMENSCB1/CSWI1.Pos.SBOw.T | Timestamp | 2019-08-23 13:44 | CO |
| SIEMENSCB1/CSWI1.Pos.SBOw.Test | BOOLEAN | False | CO |
| SIEMENSCB1/CSWI1.Pos.stSeld | BOOLEAN | False | ST |
| SIEMENSCB1/CSWI1.Pos.stVal | Dbpos | On | ST |
| SIEMENSCB1/CSWI1.Pos.t | Timestamp | 2019-08-23 13:41 | ST |
| SIEMENSCB1/GAPC1.Beh.q | Quality | [0000000000000] | ST |
| SIEMENSCB1/GAPC1.Beh.stVal | Enum | on | ST |
| SIEMENSCB1/GAPC1.Beh.t | Timestamp | 2019-08-23 13:30 | ST |
| SIEMENSCB1/GAPC1.Health.q | Quality | [0000000000000] | 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 |
| SIEMENSCB1/GAPC1.Mod.stVal | Enum | on | ST |

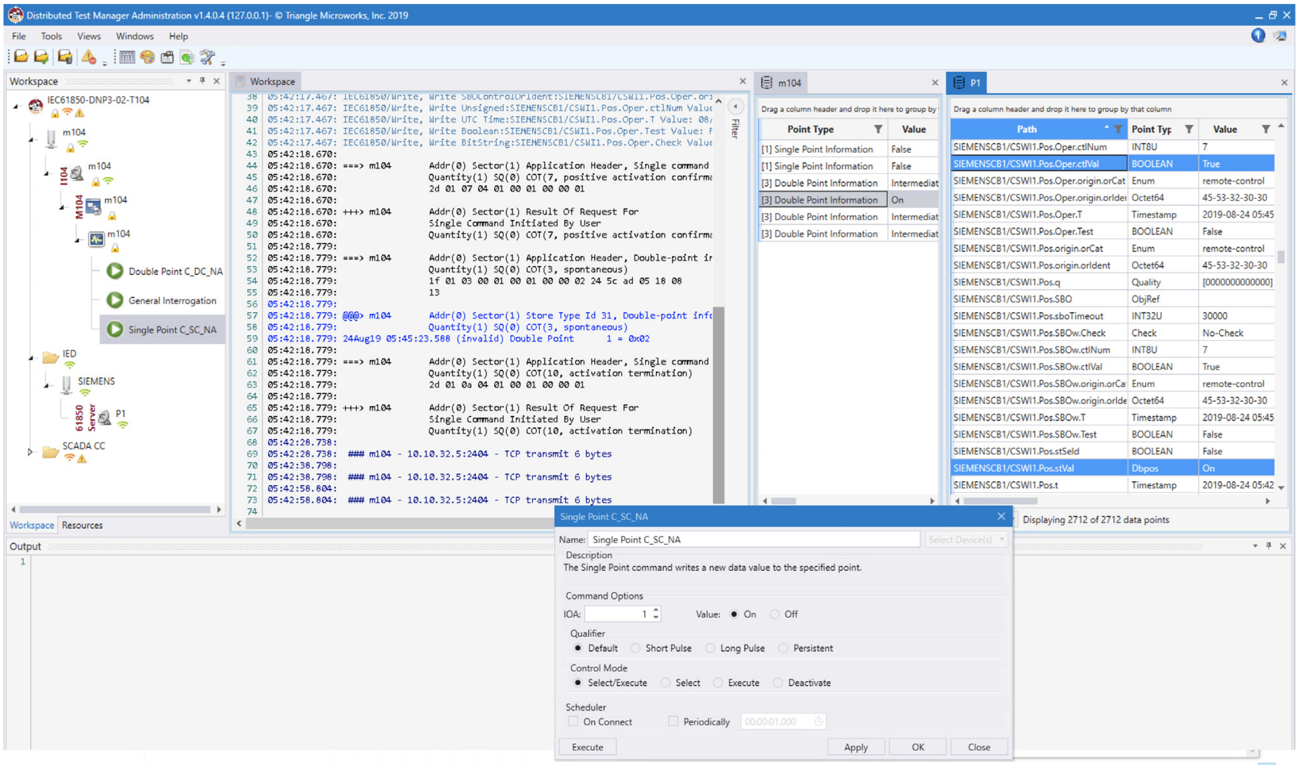
The Double Point register Pos.Oper.stVal on IED is read by the T104 General Interrogation command and the results are updated in Double Point Information register of T104 in Control Center.

## 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**



```
05:42:17.467: IEC61850/Write, Write SBOControlOrIdent:SIEMENSCB1/CSWI1.Pos.Oper.ori
05:42:17.467: IEC61850/Write, Write Unsigned:SIEMENSCB1/CSWI1.Pos.Oper.ctlNum Value
05:42:17.467: IEC61850/Write, Write UTC Time:SIEMENSCB1/CSWI1.Pos.Oper.T Value: 08/
05:42:17.467: IEC61850/Write, Write Boolean:SIEMENSCB1/CSWI1.Pos.Oper.Test Value: F
05:42:17.467: IEC61850/Write, Write BitString:SIEMENSCB1/CSWI1.Pos.Oper.Check Value
05:42:18.670:
05:42:18.670: ===> m104       Addr(0) Sector(1) Application Header, Single command
05:42:18.670:                 Quantity(1) SQ(0) COT(7, positive activation confirma
05:42:18.670:                 2d 01 07 04 01 00 01 00 00 01
05:42:18.670:
05:42:18.670: +++> m104       Addr(0) Sector(1) Result Of Request For
05:42:18.670:                 Single Command Initiated By User
05:42:18.670:                 Quantity(1) SQ(0) COT(7, positive activation confirma
05:42:18.779:
05:42:18.779: ===> m104       Addr(0) Sector(1) Application Header, Double-point ir
05:42:18.779:                 Quantity(1) SQ(0) COT(3, spontaneous)
05:42:18.779:                 1f 01 03 00 01 00 01 00 00 02 24 5c ad 05 18 08
05:42:18.779:                 13
05:42:18.779:
05:42:18.779: @@@> m104       Addr(0) Sector(1) Store Type Id 31, Double-point info
05:42:18.779:                 Quantity(1) SQ(0) COT(3, spontaneous)
05:42:18.779: 24Aug19 05:45:23.588 (invalid) Double Point      1 = 0x02
05:42:18.779:
05:42:18.779: ===> m104       Addr(0) Sector(1) Application Header, Single command
05:42:18.779:                 Quantity(1) SQ(0) COT(10, activation termination)
05:42:18.779:                 2d 01 0a 04 01 00 01 00 00 01
05:42:18.779:
05:42:18.779: +++> m104       Addr(0) Sector(1) Result Of Request For
05:42:18.779:                 Single Command Initiated By User
05:42:18.779:                 Quantity(1) SQ(0) COT(10, activation termination)
05:42:28.738:
05:42:28.738:  ### m104 - 10.10.32.5:2404 - TCP transmit 6 bytes
05:42:38.798:
05:42:38.798:  ### m104 - 10.10.32.5:2404 - TCP transmit 6 bytes
05:42:58.804:
05:42:58.804:  ### m104 - 10.10.32.5:2404 - TCP transmit 6 bytes
```

Drag a column header and drop it here to group by t

| Point Type | Value |
|---|---|
| [1] Single Point Information | False |
| [1] Single Point Information | False |
| [3] Double Point Information | Intermediat |
| [3] Double Point Information | On |
| [3] Double Point Information | Intermediat |
| [3] Double Point Information | Intermediat |

Drag a column header and drop it here to group by that column

| Path | Point Typ | Value |
|---|---|---|
| SIEMENSCB1/CSWI1.Pos.Oper.ctlNum | INT8U | 7 |
| SIEMENSCB1/CSWI1.Pos.Oper.ctlVal | BOOLEAN | True |
| SIEMENSCB1/CSWI1.Pos.Oper.origin.orCat | Enum | remote-control |
| SIEMENSCB1/CSWI1.Pos.Oper.origin.orIdei | Octet64 | 45-53-32-30-30 |
| SIEMENSCB1/CSWI1.Pos.Oper.T | Timestamp | 2019-08-24 05:45 |
| SIEMENSCB1/CSWI1.Pos.Oper.Test | BOOLEAN | False |
| SIEMENSCB1/CSWI1.Pos.origin.orCat | Enum | remote-control |
| SIEMENSCB1/CSWI1.Pos.origin.orIdent | Octet64 | 45-53-32-30-30 |
| SIEMENSCB1/CSWI1.Pos.q | Quality | [0000000000000] |
| SIEMENSCB1/CSWI1.Pos.SBO | ObjRef | |
| SIEMENSCB1/CSWI1.Pos.sboTimeout | INT32U | 30000 |
| SIEMENSCB1/CSWI1.Pos.SBOw.Check | Check | No-Check |
| SIEMENSCB1/CSWI1.Pos.SBOw.ctlNum | INT8U | 7 |
| SIEMENSCB1/CSWI1.Pos.SBOw.ctlVal | BOOLEAN | True |
| SIEMENSCB1/CSWI1.Pos.SBOw.origin.orCa | Enum | remote-control |
| SIEMENSCB1/CSWI1.Pos.SBOw.origin.orIde | Octet64 | 45-53-32-30-30 |
| SIEMENSCB1/CSWI1.Pos.SBOw.T | Timestamp | 2019-08-24 05:45 |
| SIEMENSCB1/CSWI1.Pos.SBOw.Test | BOOLEAN | False |
| SIEMENSCB1/CSWI1.Pos.stSeld | BOOLEAN | False |
| SIEMENSCB1/CSWI1.Pos.stVal | Dbpos | On |
| SIEMENSCB1/CSWI1.Pos.t | Timestamp | 2019-08-24 05:42 |

Displaying 2712 of 2712 data points

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  Value: ● On ○ Off

Qualifier
● Default ○ Short Pulse ○ Long Pulse ○ Persistent

Control Mode
● Select/Execute ○ Select ○ Execute ○ Deactivate

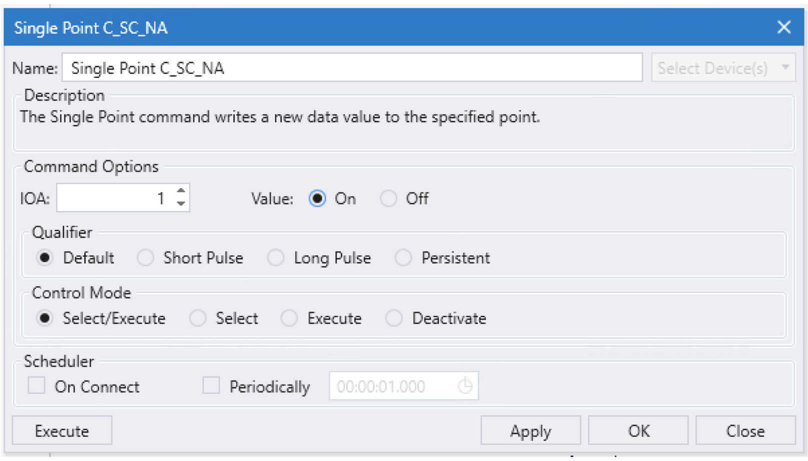
Scheduler
□ On Connect □ Periodically 00:00:01.000

Execute  Apply  OK  Close

- 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



Name: Single Point C_SC_NA

Description
The Single Point command writes a new data value to the specified point.

Command Options
IOA: 1    Value: ● On ○ Off

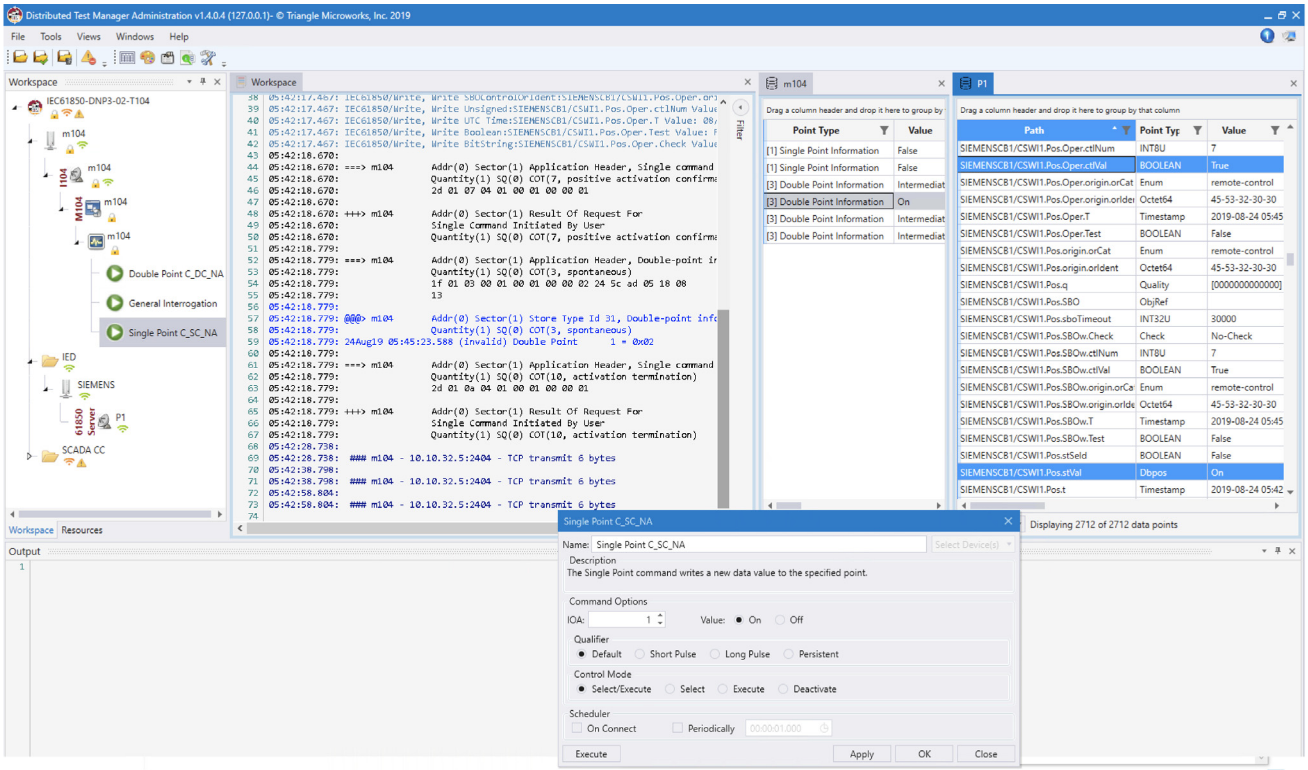
Qualifier
● Default ○ Short Pulse ○ Long Pulse ○ Persistent

Control Mode
● Select/Execute ○ Select ○ Execute ○ Deactivate

Scheduler
□ On Connect □ Periodically 00:00:01.000

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



```
05:42:17.467: IEC61850/Write, Write SBOControlOrIdent:SIEMENSCB1/CSWI1.Pos.Oper.ori
05:42:17.467: IEC61850/Write, Write Unsigned:SIEMENSCB1/CSWI1.Pos.Oper.ctlNum Value
05:42:17.467: IEC61850/Write, Write UTC Time:SIEMENSCB1/CSWI1.Pos.Oper.T Value: 08/
05:42:17.467: IEC61850/Write, Write Boolean:SIEMENSCB1/CSWI1.Pos.Oper.Test Value: F
05:42:17.467: IEC61850/Write, Write BitString:SIEMENSCB1/CSWI1.Pos.Oper.Check Value
05:42:18.670:
05:42:18.670: ===> m104       Addr(0) Sector(1) Application Header, Single command
05:42:18.670:                 Quantity(1) SQ(0) COT(7, positive activation confirma
05:42:18.670:                 2d 01 07 04 01 00 01 00 00 01
05:42:18.670:
05:42:18.670: +++> m104       Addr(0) Sector(1) Result Of Request For
05:42:18.670:                 Single Command Initiated By User
05:42:18.670:                 Quantity(1) SQ(0) COT(7, positive activation confirma
05:42:18.779:
05:42:18.779: ===> m104       Addr(0) Sector(1) Application Header, Double-point ir
05:42:18.779:                 Quantity(1) SQ(0) COT(3, spontaneous)
05:42:18.779:                 1f 01 03 00 01 00 01 00 00 02 24 5c ad 05 18 08
05:42:18.779:                 13
05:42:18.779:
05:42:18.779: @@@> m104       Addr(0) Sector(1) Store Type Id 31, Double-point info
05:42:18.779:                 Quantity(1) SQ(0) COT(3, spontaneous)
05:42:18.779: 24Aug19 05:45:23.588 (invalid) Double Point      1 = 0x02
05:42:18.779:
05:42:18.779: ===> m104       Addr(0) Sector(1) Application Header, Single command
05:42:18.779:                 Quantity(1) SQ(0) COT(10, activation termination)
05:42:18.779:                 2d 01 0a 04 01 00 01 00 00 01
05:42:18.779:
05:42:18.779: +++> m104       Addr(0) Sector(1) Result Of Request For
05:42:18.779:                 Single Command Initiated By User
05:42:18.779:                 Quantity(1) SQ(0) COT(10, activation termination)
05:42:28.738:
05:42:28.738:  ### m104 - 10.10.32.5:2404 - TCP transmit 6 bytes
05:42:38.798:
05:42:38.798:  ### m104 - 10.10.32.5:2404 - TCP transmit 6 bytes
05:42:58.804:
05:42:58.804:  ### m104 - 10.10.32.5:2404 - TCP transmit 6 bytes
```

m104

Drag a column header and drop it here to group by

| Point Type | Value |
|---|---|
| [1] Single Point Information | False |
| [1] Single Point Information | False |
| [3] Double Point Information | Intermediat |
| [3] Double Point Information | On |
| [3] Double Point Information | Intermediat |
| [3] Double Point Information | Intermediat |

P1

Drag a column header and drop it here to group by that column

| Path | Point Typ | Value |
|---|---|---|
| SIEMENSCB1/CSWI1.Pos.Oper.ctlNum | INT8U | 7 |
| SIEMENSCB1/CSWI1.Pos.Oper.ctlVal | BOOLEAN | True |
| SIEMENSCB1/CSWI1.Pos.Oper.origin.orCat | Enum | remote-control |
| SIEMENSCB1/CSWI1.Pos.Oper.origin.orIde | Octet64 | 45-53-32-30-30 |
| SIEMENSCB1/CSWI1.Pos.Oper.T | Timestamp | 2019-08-24 05:45 |
| SIEMENSCB1/CSWI1.Pos.Oper.Test | BOOLEAN | False |
| SIEMENSCB1/CSWI1.Pos.origin.orCat | Enum | remote-control |
| SIEMENSCB1/CSWI1.Pos.origin.orIdent | Octet64 | 45-53-32-30-30 |
| SIEMENSCB1/CSWI1.Pos.q | Quality | [000000000000] |
| SIEMENSCB1/CSWI1.Pos.SBO | ObjRef | |
| SIEMENSCB1/CSWI1.Pos.sboTimeout | INT32U | 30000 |
| SIEMENSCB1/CSWI1.Pos.SBOw.Check | Check | No-Check |
| SIEMENSCB1/CSWI1.Pos.SBOw.ctlNum | INT8U | 7 |
| SIEMENSCB1/CSWI1.Pos.SBOw.ctlVal | BOOLEAN | True |
| SIEMENSCB1/CSWI1.Pos.SBOw.origin.orCa | Enum | remote-control |
| SIEMENSCB1/CSWI1.Pos.SBOw.origin.orIde | Octet64 | 45-53-32-30-30 |
| SIEMENSCB1/CSWI1.Pos.SBOw.T | Timestamp | 2019-08-24 05:45 |
| SIEMENSCB1/CSWI1.Pos.SBOw.Test | BOOLEAN | False |
| SIEMENSCB1/CSWI1.Pos.stSeld | BOOLEAN | False |
| SIEMENSCB1/CSWI1.Pos.stVal | Dbpos | On |
| SIEMENSCB1/CSWI1.Pos.t | Timestamp | 2019-08-24 05:42 |

Displaying 2712 of 2712 data points

Single Point C_SC_NA

Name: Single Point C_SC_NA

Description
The Single Point command writes a new data value to the specified point.

Command Options
IOA: 1    Value: ● 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 OK Close

- 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

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-c78-741709.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

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 |
| IoT | 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 |
| TCP | Transmission Control Protocol |
| TMW | Triangle MicroWorks |