White paper
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Transporting serial SCADA traffic between the RTU and the Control Center over Cisco MPLS Pseudowire Technology

White Paper

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Contents

Introduction

Electronic access points for high impact BES cyber systems require inbound and outbound access permission, including the reason for granting access, and deny all other access by default. To satisfy this NERC CIP standard requirement firewalls need to be deployed on each transmission substation for inspecting SCADA traffic transported using IP-based raw socket transport or protocol translation mechanism. Cisco Serial Pseudowire over MPLS or MPLS Segment Routing is a new feature designed to transport SCADA application traffic. It does so without needing IP transport, eliminating the need to deploy thousands of firewalls in transmission substations and control centers.

Substation Automation Utility WAN Solution Architecture

The Cisco Substation Automation Utility WAN Solution Architecture is described below.

- Utility owned MPLS backhaul network
- Cisco Industrial Router IR8340 acting as on net MPLS PE and Substation Router
- Legacy RTU connect to Substation Router via Serial interface
- Cisco Industrial Router IR8340 acts as Transmission System Operator (TSO) control center router for aggregation legacy SCADA sessions from various substations
- SCADA application server is hosted on the control center
- SCADA application or Front-end Processor RS232 interface (if supported) can be connected to async serial interface of control center PE Router. In this scenario scale will be limited to number of physical RS232 ports supported on control center PE router
- If SCADA FEP has an ethernet interface it will be connected to the center PE router ethernet interface via substation LAN and firewall.

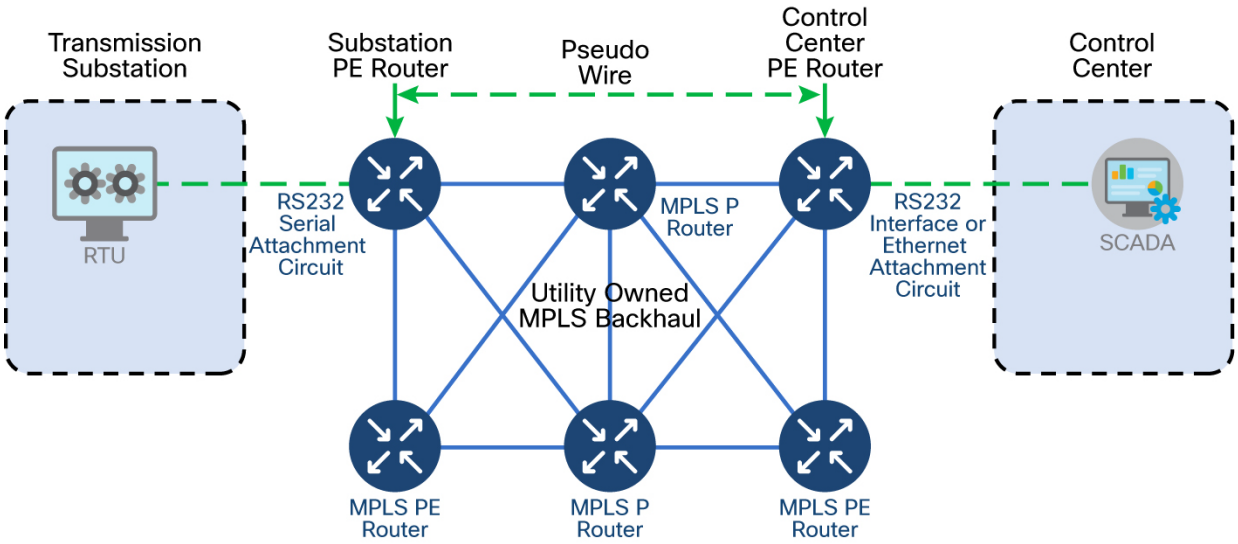

Figure 1

Substation Automation Utility WAN Architecture

For detailed information about the Cisco Substation Automation solution, refer to the latest validated design for Substation Automation: https://www.cisco.com/c/dam/en/us/td/docs/solutions/Verticals/Utilities/SA/3-1/SA-3-2-DG.pdf

SCADA Protocols and Information Communication Technologies (ICT) supported by Cisco

The figure below depicts the ICT technologies supported by Cisco.

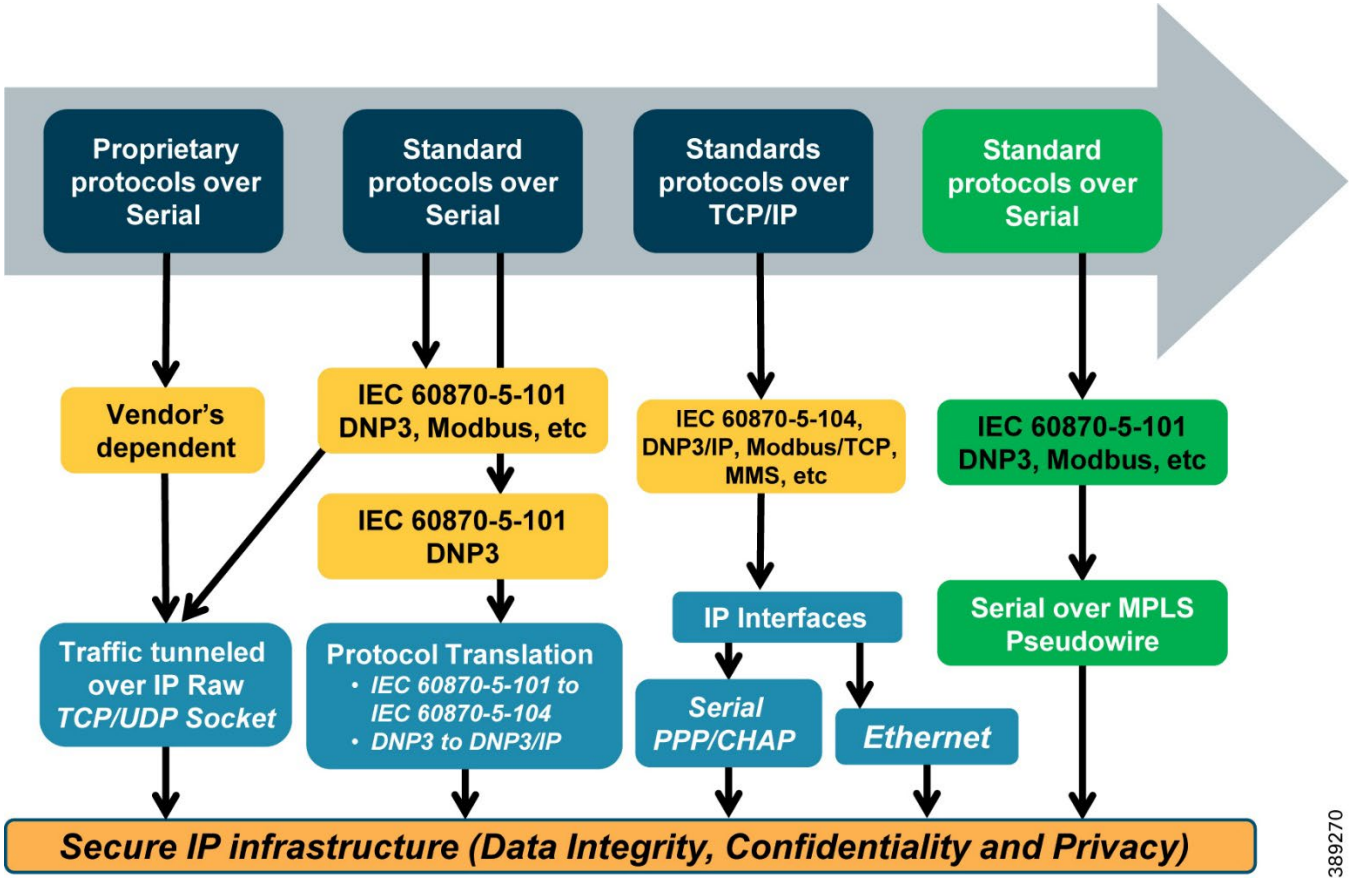

Figure 2
Cisco SCADA ICT Technology

Standard IP routing, raw socket, and protocol translation are various ICT for transporting SCADA traffic which will require firewall inspection at a transmission substation. When using the Serial over MPLS Pseudowire technique, it eliminates the need for firewall inspection at the substation level and simplifies application traffic inspection requirements only at the control center.

For more information refer to:

https://www.cisco.com/c/en/us/td/docs/routers/ir8340/software/configuration/1717x/b_ir8340_cg_17-17-x/m_serial-mpls-pseudowire.html

Serial to Serial Pseudowire Deployment Scenario

The legacy RTU is connected to the substation router on the RS232 serial interface which acts as an attachment circuit. On the Control Center side, the SCADA Front End Processor (FEP) is connected to the Control Center PE Router via the serial (RS232) interface. Serial Pseudowire over MPLS switches both attachment circuits to enable SCADA to RTU communication. In this deployment option, scale is limited to the number of physical serial interfaces on the Control Center PE Router. See Figure 3.

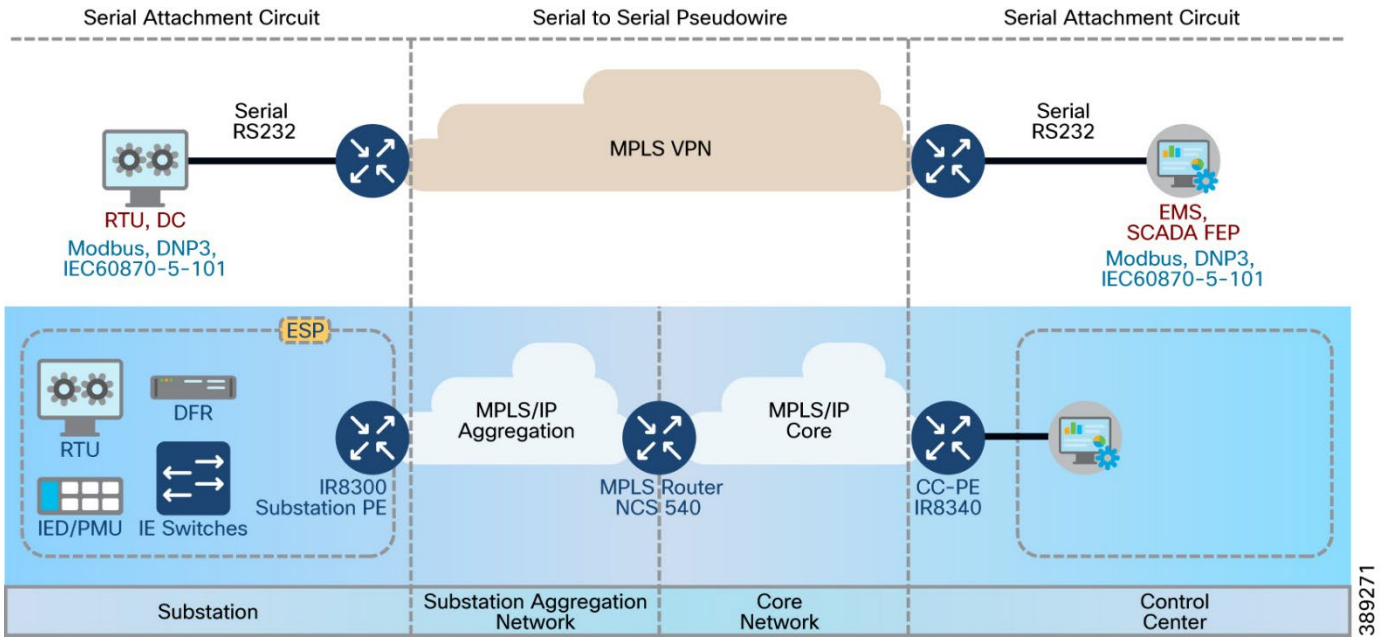

Figure 3

Serial to Serial Pseudowire

Substation Router hardware and configuration

- Serial module details
    - PID: IRM-NIM-RS232
    - DESCR: " 8-Port synchronous and asynchronous serial network interface module“

- Serial interface connecting to Legacy RTU configuration

```
interface Serial0/3/0
 physical-layer async
 mtu 1514
 no ip address
```

load-interval 30

cdp enable

xconnect 21.21.1.1 2052 encapsulation mpls pw-class SERIAL_TO_SERIAL

- Loopback and MPLS Pseudowire configuration

interface Loopback22

ip address 21.21.1.2 255.255.255.255

pseudowire-class SERIAL_TO_SERIAL

encapsulation mpls

status

status control-plane route-watch

switching tlv

For standard MPLS configuration refer to https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/mp_basic/configuration/xe-16/mp-basic-xe-16-book/multiprotocol-label-switching-mpls-on-cisco-routers.html

Headend PE Router configuration

For this use case the Cisco IR8340 Router can only act as a Headend Router.

Loopback and MPLS PW configuration

pseudo wire-class SERIAL_TO_SERIAL

encapsulation mpls

status

status control-plane route-watch

switching tlv

interface Loopback22

ip address 21.21.1.1 255.255.255.255

interface Serial0/3/7

```
 description interface connection to SCADA FEP
  physical-layer async
  mtu 1514
  no ip address
  load-interval 30
  cdp enable
  xconnect 21.21.1.2 2052 encapsulation mpls pw-class SERIAL-SERIAL
 end
```

Serial to Ethernet Interworking Pseudowire Scenario

Legacy RTU will be connected to substation router on RS232 serial interface which acts as an attachment circuit. Pseudowire xconnect (serial to ethernet bridged interworking) is provisioned on same serial interface to transport the legacy SCADA traffic from substation to the TSO control center Provider Edge (PE) Router. Pseudowire is terminated on the loopback interface on the control center PE router. The raw socket TCP client is provisioned on same loopback interface to transport the RTU traffic to SCADA Front End Processor (FEP) application which is connected to LAN side of control center PE router via firewall. See Figure 4.

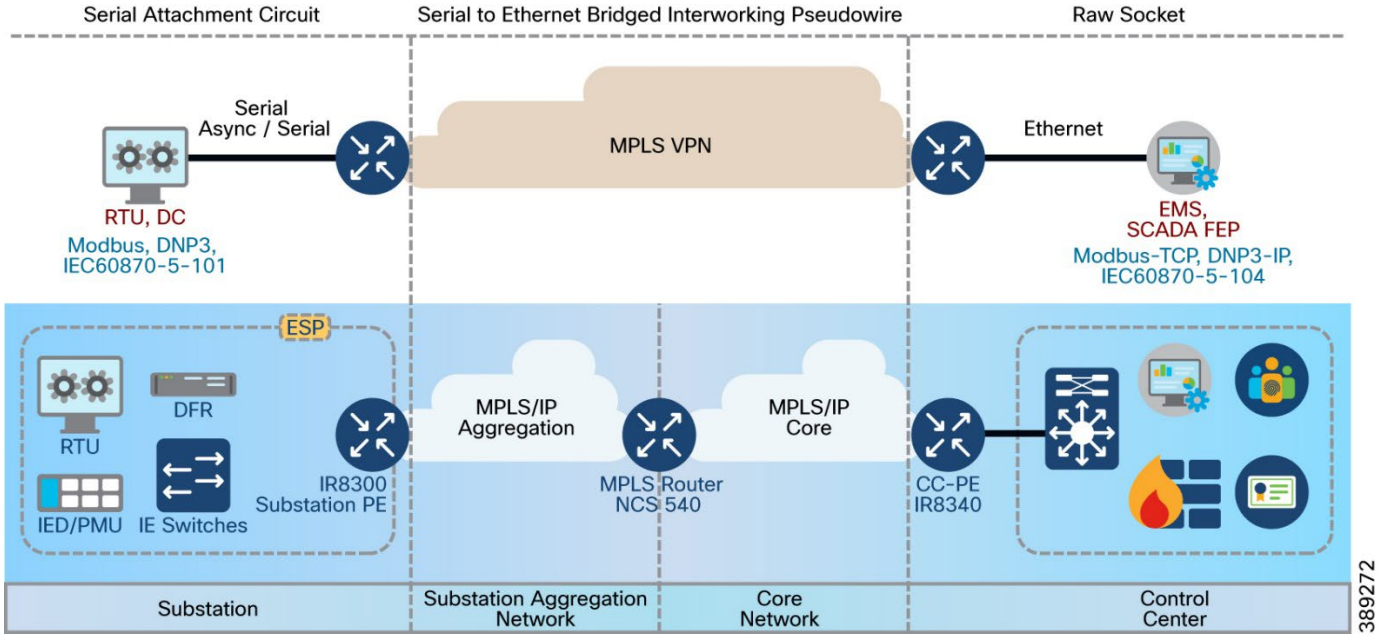

Figure 4

Serial to Ethernet Interworking Pseudowire

Substation Router hardware and configuration

Serial module details

- PID: IRM-NIM-RS232
- DESCR: " 8-Port synchronous and asynchronous serial network interface module“

Serial interface connecting to Legacy RTU configuration

```
interface Serial0/3/0
 physical-layer async
 mtu 1514
 no ip address
 load-interval 30
 cdp enable
 xconnect 21.21.1.1 2052 encapsulation mpls pw-class SERIAL_TO_ETH
```

Loopback and MPLS Psuedowire configuration

```
interface Loopback22
 ip address 21.21.1.2 255.255.255.255

pseudowire-class SERIAL_TO_ETH
 encapsulation mpls
interworking ethernet
  no status
 no status control-plane route-watch
 no switching tlv
```

Headend PE Router configuration

For this use case, the Cisco IR8340 Router only can act as a Headend Router.

There is no need for serial interfaces on the headend PE router.

Loopback, MPLS PW and raw socket configuration

```
pseudo wire-class SERIAL_TO_ETH
 encapsulation mpls
 interworking ethernet
 no status
 no status control-plane route-watch
 no switching tlv

interface Loopback22
 ip address 21.21.1.1
raw-socket tcp client 192.168.4.171 33052 192.168.201.71
xconnect 21.21.1.2 2052 encapsulation mpls pw-class SERIAL_TO_ETH
```

Design Considerations for SCADA over Pseudowire

- Utility-owned MPLS Backhaul Network
- Substation and Control Center Routers are part of the MPLS Network acting in the PE Role
- The IR8340 series router is deployed as both Substation and Control Center PE
- TSO Control Center PE can aggregate 1000 Pseudowires, for example, Substation Routers deployed in a Serial to Ethernet Interworking scenario
- TSO Control Center PE router is deployed only to aggregate Legacy SCADA connections and optionally as a zone-based firewall
- Use Cisco IOSXE software releases 17.17.1 or later

Known Limitations

- Pseudowire redundancy feature is not supported.
- Dedicated control center Router is used for legacy SCADA termination
- Raw Socket TCP client packetization sub options like packet length, timer, or special characters are not supported
- TCP Server and UDP Server support Raw Socket on the Control Center PE Router

Conclusion

When looking to transport legacy SCADA traffic from a transmission substation to the TSO control center (and vice versa) in a simplified and cost-effective way, the Cisco Serial over Pseudowire is the preferred technology. It eliminates the need for firewall inspection at the substation and control center.

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