Precision Time Protocol for NCS 2000 Network

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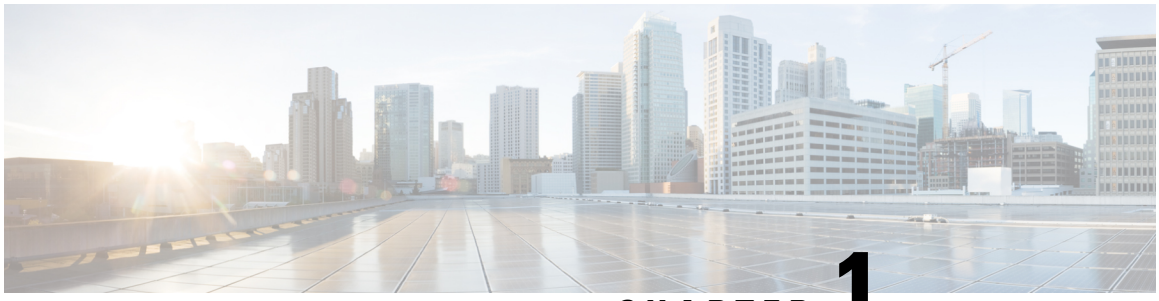
CONTENTS



CHAPTER 1

Overview of PTP Solution

Overview of PTP

Challenges

In today's fast growing network traffic, network operators are adding new nodes to ensure smooth traffic flow in data centers and networks. Addition of new nodes increases the latency of data over the networks. Network latency poses huge challenge for network operators. To avoid delays in synchronizing time signals and latency in the network, the need for precise timing synchronization is on the rise. PTP offers synchronizing timing solution across networks with high precision.

Solution

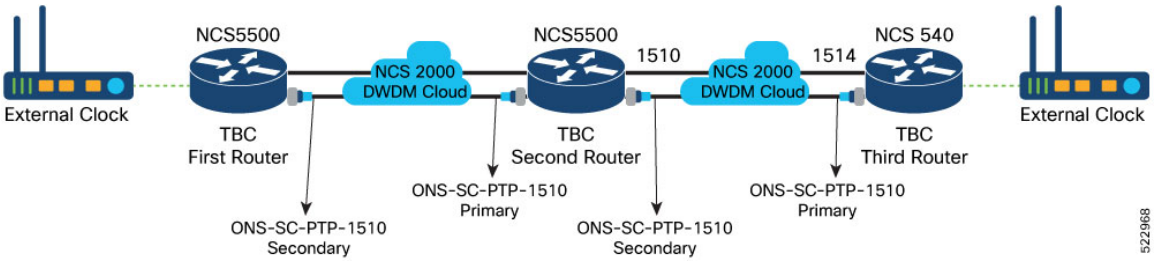
Cisco has devised the PTP solution over NCS 2000 networks to help you avoid latency and ensure timing synchronization in your networks. NCS 2000 provides the operational capacity to meet your ever-increasing network needs. PTP for the NCS 2000 networks combines the operational functionality of NCS 2000 and precise PTP synchronization to enhance the efficiency of your networks. You can implement this solution over an existing NCS 2000 optical network using NCS 5500 and NCS 540.

The NCS 5500 and NCS 540 routers provide PTP support to the NCS 2000 networks. The solution leverages the PTP signal from NCS 5500 and NCS 540 to provide a path for transparent clock synchronization over the NCS 2000 network.

Previously, the NCS 2000 networks used an in-band channel to send PTP signal from NCS 5500 and NCS 540 through the network to synchronize timing reference. PTP signal that is sent over an in-band channel limited users from utilizing the entire NCS 2000 bandwidth. The PTP filter is introduced to propagate the PTP signal through an out-of-band OSC signal at 1518 nm. Keeping all in-band channels available for carrying traffic, this filter enables you to utilize all the channels in the NCS 2000 networks.

In the following example, the Grandmaster (GM) clock feeds the PTP signals to the NCS 5500 router (First Router) through a primary clock (TBC). The ONS-SC-PTP-1510 pluggable that is installed in the NCS 55xx router enables the router to synchronize timing signals over the NCS 2000 DWDM cloud.

Figure 1: PTP Solution for NCS 2000 DWDM Cloud Using NCS 5500 and NCS 540 Routers



On the NCS 55xx router side, the PTP (optical clock) signal is generated using an external clock that acts as the GM clock. The GM clock synchronizes the PTP signal with Boundary Clocks (BC), both primary and secondary clocks, which are distributed over the network. Primary clocks initiate their own PTP session with downstream secondary clocks to mitigate the number of network hops and packet delays between the GM and secondary clocks. The ONS-SC-PTP-1510 and ONS-SC-PTP-1514 pluggable optics are introduced to support the NCS 55xx routers to propagate the PTP clock signals over the NCS 2000 DWDM cloud.

The PTP solution is implemented using SFP pluggable optics and a PTP filter. The PTP filter combines and splits the PTP and OSC signals in the NCS 2000 network. The pluggable optics are inserted in the NCS 5500 and NCS 540 routers to send the PTP signal. This solution requires the following pluggable optics and filter:

Table 1: Hardware Specifications

Product ID	Description
ONS-SC-PTP-1510	Multirate GE, FE pluggable optics, 1510 nm, C-temp
ONS-SC-PTP-1514	Multirate GE, FE pluggable optics, 1514 nm, C-temp
15216-OSC-PTP	Passive OSC-PTP coupler filter, 1510 nm, 1514 nm, 1518 nm

PTP Filter

PTP filter enables multiplexing and demultiplexing of the OSC and PTP signals over the NCS 2000 networks. The filter is introduced to send the PTP signal over an OOB OSC channel in the NCS 2000 networks. The filter receives the PTP signal from NCS 5500 or 540 and the OSC signal from the NCS 2000 controller cards. It combines both the signals and sends the PTP signal over a line card OSC channel in the NCS 2000 network.

An SFP in the NCS 5500 or 540 router sends the PTP signal at 1510 or 1514 nm to the filter. The controller card sends the OSC signal at 1518 nm to the filter. The filter sends the combined signal through an OSC channel of the NCS 2000 line cards. The filter is connected to the routers and cards on east and west sides for PTP transmission.

PTP Pluggable Optics

PTP pluggable optics enable transmission of the PTP signals to the NCS 2000 DWDM networks. PTP SFPs are hosted on routers such as NCS 540 or NCS 55xx that support sending and receiving PTP signals. The PTP pluggable optics come in two variants, each for 1510 and 1514 nm respectively. Both variants support DWDM

transmission at 1 Gbps. The optics are designed as bidirectional to avoid the latency that arises with up and down fibers in full duplex communication.

The ONS-SC-PTP-1510 pluggable sends PTP signal at 1510-nm wavelength and can receive 1514-nm signals from the other end.

The ONS-SC-PTP-1514 pluggable sends PTP signal at 1514-nm wavelength and can receive 1510-nm signals from the other end.

Note When using these pluggable optics for intralab connectivity, you must add an appropriate attenuator (15 or 20 dB) to the optics in the connection.

Bring Up of PTP Over OSC Link Workflow

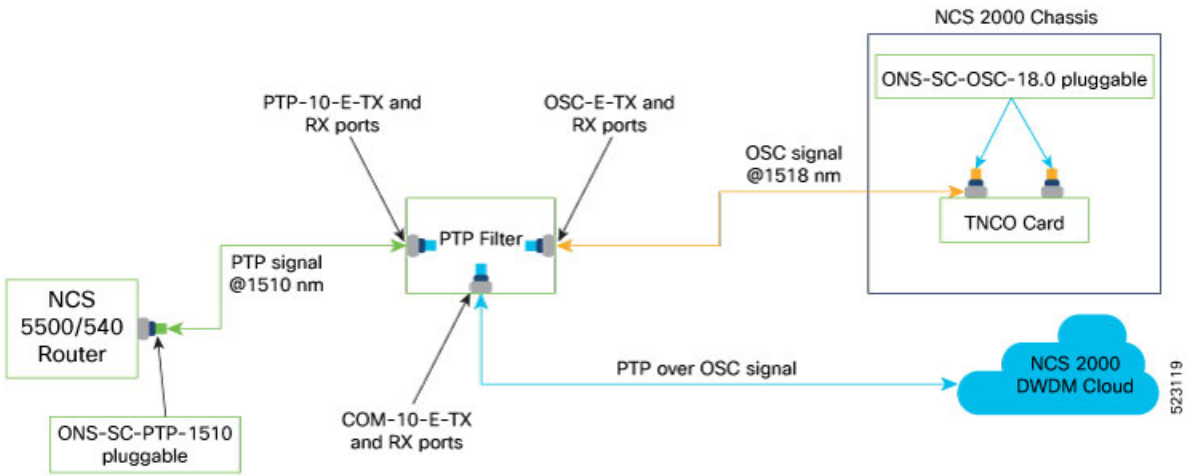
The following workflow brings up the PTP over OSC link for the NCS 2000 networks:

1. Install Cisco ONS 15216 OSC PTP Filter Module on NCS 2000 networks. See Installation section in the *Installing the Cisco ONS 15216 DWDM and CWDM Passive Optical Modules* book.
2. Ground PTP module and clean module ports. See Ground Description section in *Installing the Cisco ONS 15216 DWDM and CWDM Passive Optical Modules* book.
3. Connect cables. See PTP Module Port Connections, on page 3.
4. Configure PTP Clock Signal. See Configuration of PTP Clock Signal, on page 4.

PTP Module Port Connections

The following image shows the PTP filter port connections with NCS 5500 / NCS 540 and TNCS-2O in NCS 2000.

Figure 2: PTP Filter Port Connections Block Diagram



The preceding image shows the PTP over OSC signal entering the NCS 2000 DWDM cloud. Many PTP filters are required in the network for free flow of the PTP over OSC signal.

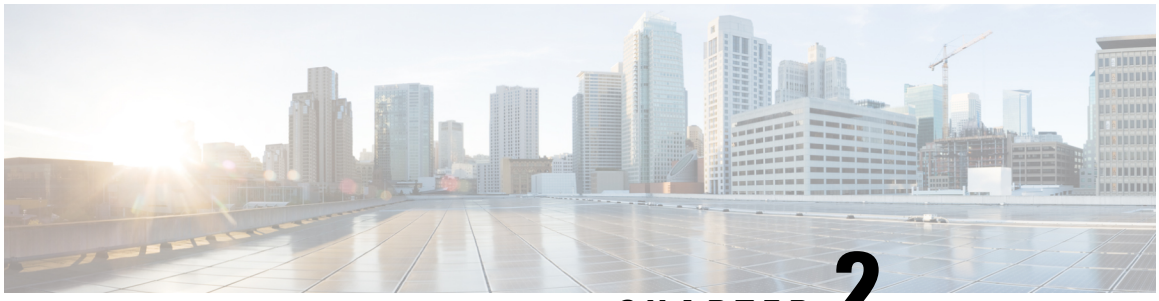
The following table provides the cabling connection between the router and controller card with the PTP filter for both east and west direction.

Table 2: West and East Port Connections of the PTP Filter Module

NCS 5500 / NCS 540 Router Side	**NCS 2000 Controller Card Side**		**To PTP Filter (West)**		**From PTP Filter (East)**	**NCS 2000 Controller Card Side**		**NCS 5500 / NCS 540 Router Side**
Pluggable Optics	**Controller Card**	**Port (Pluggable)**	**Ports**		**Ports**	**Controller Card**	**Port (Pluggable)**	**Pluggable Optics**
—	TNSC-2O (TX)	OTDR/ OSC embedded ports (ONSC-OSC-18)	OSC-W-RX	**Column Left Empty Intentionally**	OSC-E-RX	TNSC-2O (TX)	OTDR/ OSC embedded ports (ONSC-OSC-18)	—
	TNSC-2O (RX)		OSC-W-TX		OSC-E-TX	TNSC-2O (RX)		
ONSC-PIP-154 (TX)	—		PIP-14-W-RX		PIP-10-E-RX	—		ONSC-PIP-150 (TX)
ONSC-PIP-154 (RX)			PIP-14-W-TX		PIP-10-E-TX			ONSC-PIP-150 (RX)

Configuration of PTP Clock Signal

The PTP signal can be configured only on the NCS 5500 and NCS 540 routers. PTP solution examples that are provided in this guide support only the **G.8275.1** profile. For more information on the PTP signal configuration, see Configuring Precision Time Protocol.



CHAPTER 2

Use Cases and Limitations

Use Case

The PTP solution for NCS 2000 enables leveraging the PTP signals from the NCS 5500 and NCS 540 routers over the NCS 2000 networks.

NCS 2000 Network Configuration for PTP over OSC Link

The PTP solution for the NCS 2000 networks is supported over the following NCS 2000 flex spectrum network configurations.

Table 3: NCS 2000 Networks

NCS 2000 Flex Spectrum Network	Components Required
PTP over OSC Link with OTDR	• Pluggables: ONS-SC-OSC-18.0, ONS-SC-PTP-1514 and ONS-SC-PTP-1510 • Filter: 15216-OSC-PTP

The following table shows the reach of the PTP over OSC link in the NCS 2000 networks with and without RAMAN amplifiers.

Table 4: Reach of the PTP over OSC Link

Signal	Condition	Span Reach (dB)	
		Without RAMAN	With RAMAN
OSC	1518 nm - FE	35	38 (33 dB at RAMAN startup, 38 dB after RAMAN is ON)
PTP	1510/1514 nm - FE	33	37 (RAMAN ON)

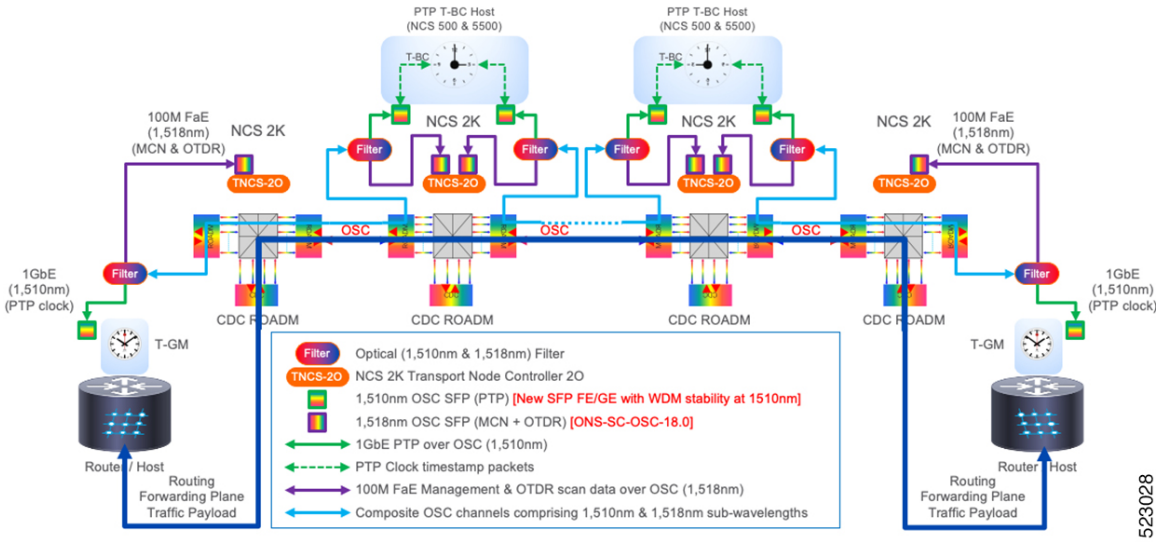
Signal	Condition	Span Reach (dB)	
		Without RAMAN	With RAMAN
PTP	1510/1514 nm - GE	30	37 (RAMAN ON

Note To limit the RX power below the allowed maximum (–7 dBm) reach, you must use attenuators with PTP SFPs.

PTP over OSC Link with OTDR using PTP Filter

This solution adds a PTP filter between the TNCS-2O card and the GM clock in the router. The PTP filter multiplexes the PTP signal from the GM clock and the OSC signal from the NCS 2000 TNSC-2O card. The filter sends the combined signal over the NCS 2000 network through the near-end ROADM. The near-end ROADM propagates the signal through its OSC channel to the far end. The combined signal is demultiplexed at the next PTP filter to send the PTP signal to NCS 55xx/540 and the OSC signal to the TNSC-2O card. This sequence of mutliplexing and demultiplexing PTP and OSC signals continue on both sides of the CDC ROADM throughout the NCS 2000 network.

Figure 3: PTP over OSC Link with OTDR Signal Flow using PTP Filter



The above image shows the signal flow of the PTP over OSC link using a PTP filter. For more information on the port connection, see PTP Module Port Connections, on page 3.

Use Case 1: PTP over OSC Link with OTDR, without RAMAN Amplifier

The following hardware is required for this use case:

- Pluggable optics: ONS-SC-OSC-18.0, ONS-SC-PTP-1514, and ONS-SC-PTP-1510
- Filter: 15216-OSC-PTP

- Amplifier: OPT-EDFA-24
- ROADM Cards: SMR20-FS (NCS2K-20-SMRFS / NCS2K-20-SMRFS-CV / NCS2K-20-SMRFS-L)

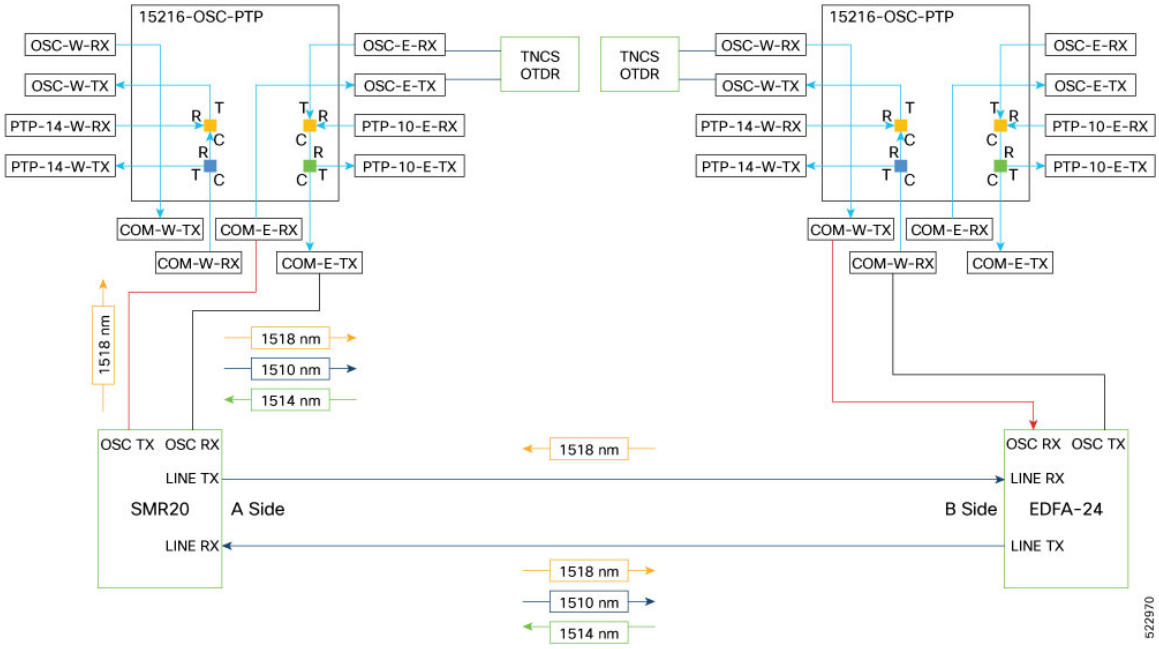
The 15216-OSC-PTP filter combines the OSC signal from the TNCS-O card and the PTP signal from the ONS-SC-PTP-1510 pluggable in NCS 55xx in the east direction. The filter sends the combined signal to the OSC RX port of the SMR20 ROADM card through the COM-E-TX port. SMR20-FS sends the combined signal to the line port on EDFA-24 line card on Side B. The EDFA-24 card sends the signal to the COM-W-RX port of the 15216-OSC-PTP filter. The 15216-OSC-PTP filter splits the signal and sends the OSC signal to the TNCS-O card via OSC-W-RX port and the PTP clock signal to the NCS 55xx router.

The following table shows the COM port connections for the PTP Filter Module.

Table 5: COM Port Connections of the PTP Filter Module

Near End		Far End	
From PTP Filter	**To SMR20**	**From EDFA-24**	**To PTP Filter**
COM-E-RX	OSC-TX	OSC-TX	COM-W-RX
COM-E-TX	OSC-RX	OSC-RX	COM-W-TX

Figure 4: PTP over OSC with OTDR, Without RAMAN Amplifier



Use Case 2: PTP over OSC Link with OTDR, RAMAN Amplifier

The following hardware is required for this use case:

- Pluggable optics: ONS-SC-OSC-18.0, ONS-SC-PTP-1514, and ONS-SC-PTP-1510
- Filter: 15216-OSC-PTP

- Amplifier: OPT-EDFA-24, 15454-M-RAMAN-CTP
- ROADM: SMR9 (NCS2K-9-SMRxxFS / NCS2K-9-SMRxxFS-L)

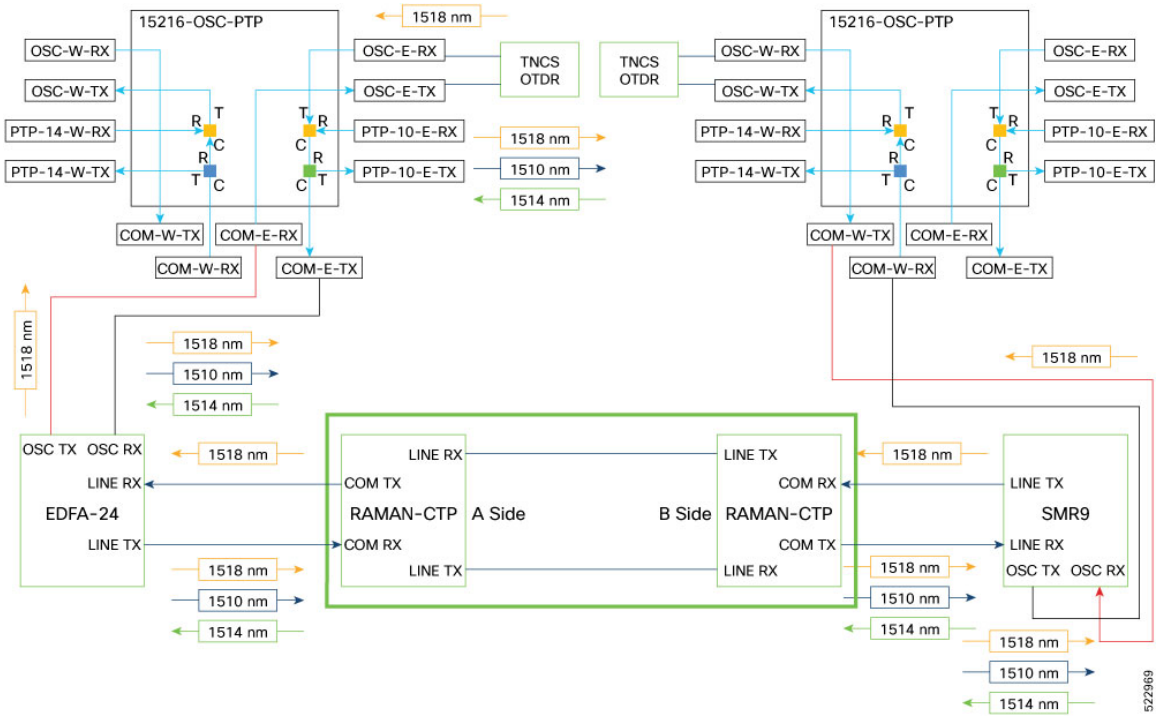
The 15216-OSC-PTP filter combines the OSC signal from the TNCS card and the PTP clock signal from the ONS-SC-PTP-1510 pluggable in NCS 55xx in the east direction. The filter sends the combined signal to the OSC RX port of the EDFA-24 (OPT-EDFA-24) amplifier card through the COM-E-TX port. EDFA-24 sends the combined signal via RAMAN-CTP amplifier on Side A and B to the SMR9 ROADM card. The SMR card sends the signal to the COM-W-RX port of the 15216-OSC-PTP filter. The 15216-OSC-PTP filter splits the signal via OSC-W-RX port and sends the PTP signal to boundary clock and the OSC signal to the TNCS card.

The following table shows the COM port connections for the PTP Filter Module.

Table 6: COM Port Connections of the PTP Filter Module

Near End		Far End	
From PTP Filter	**To EDFA-24**	**From SMR9**	**To PTP Filter**
COM-E-RX	OSC-TX	OSC-TX	COM-W-RX
COM-E-TX	OSC-RX	OSC-RX	COM-W-TX

Figure 5: Sending PTP over OSC Link with OTDR and RAMAN Amplifier



Limitations in PTP for NCS 2000 Networks

The PTP solution has a few limitations in the different use cases that it supports. The following sections provide the limitations that exist in the PTP solution.

NCS 2000 Network with PTP Filter

The following table shows the limitations that are found in the NCS 2000 networks that have PTP filters:

Table 7: Limitations in NCS 2000 Network with PTP Filter

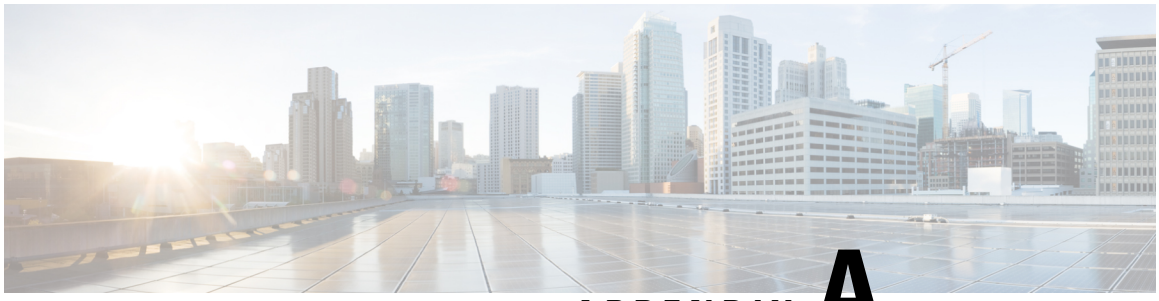
Scenario	Impacted Areas	Description
Sending OSC and PTP combined signals through the DWDM cloud.	OSC alarm management	If OSC is not present in the composite signal, then alarms related to OSC do not function properly.
	Current OSC Optics PM	The OSC RX/TX always reads or displays the composite power (OSC + PTP). If the OSC signal fails, the OSC PM statistics cannot be extracted from the composite signal. The port always displays Optics statistics, irrespective of whether OSC is present or not.
	Existing OSC TCA Monitoring	OSC TCA cannot be managed from the composite signal.
Requesting for an OTDR fast scan.	Existing alarm management	Incoming Overhead Loss of Signal (LOS-O) alarm does not report, when fast scan is in-progress.
Using an EDRA-x-y span	PTP solution	EDRA span does not work due to OSC pass band limitation.

NCS 5500 Router

The following table shows the limitations that exist in the NCS 5500 router:

Table 8: Limitations on the NCS 5500 Router

Limitations	Impacted Areas
Interface state flaps with Up/Down events, when the receive power is less than –41.54 dBm.	1. PTP state is impacted. 2. Router console floods with the Up/Down events.



APPENDIX A

Appendix

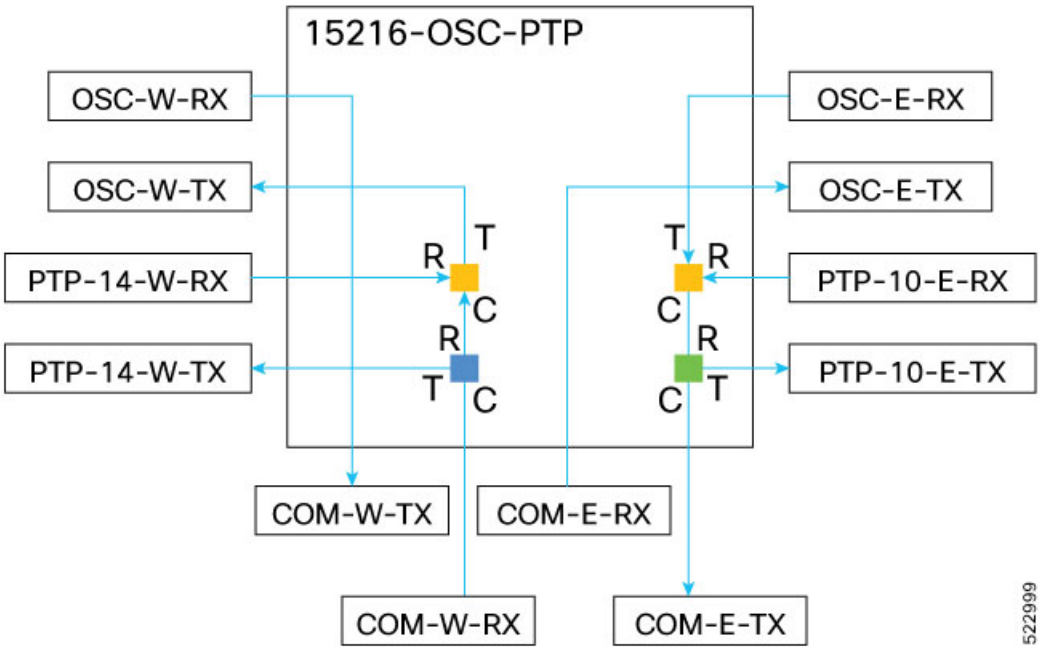
Cisco ONS 15216 OSC PTP Filter Module

The Cisco ONS 15216-OSC-PTP Filter module is used in the NCS 2000 network to multiplex and demultiplex the optical signals that are provided by the DWDM SFPs. The module carries the PTP signal at 1510 and 1514 nm and the standard OSC signal at 1518 nm.

The following lists the module's operations:

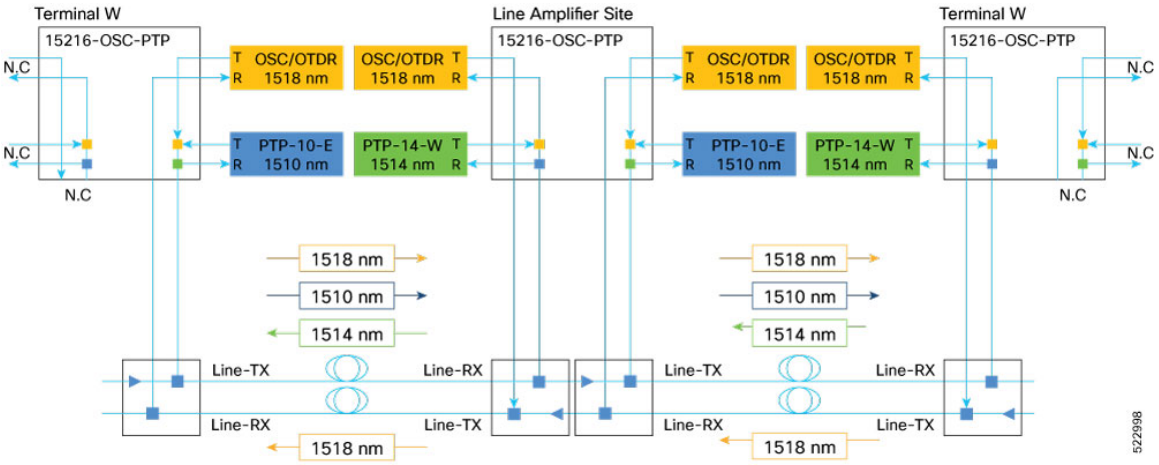
- The 1510- and 1518-nm wavelengths are separated from the composite signal entering the COM-W-RX port, and routed toward the PTP-14-W-TX and OSC-W-TX ports respectively.
- The 1514-nm wavelength is received from the PTP-14-W-RX port, and combined toward the COM-W-RX port.
- On the other direction, the 1518- and 1510-nm wavelengths are received respectively from the OSC-E-RX and PTP-10-E-RX ports, and combined toward the COM-E-TX port.
- The 1514-nm wavelength entering the COM-E-TX port is separated, and routed to the PTP-10-E-TX port.
- The path from OSC-W-RX to COM-W-TX is a simple bypass path (no filtering). The same bypass path applies for the COM-E-RX to OSC-E-TX ports.

Figure 6: 15216-OSC-PTP Filter Module Optical Block Diagram



Note The filter propagates the 1510 and 1514-nm signals on the same optical fiber between two adjacent nodes in the opposite direction.

Figure 7: OSC + PTP Signal Transmission Block Diagram



Features

The Cisco ONS 15216-OSC-PTP Filter module has the following features:

- Thin-film DWDM 100GHz-spaced filters for multiplexing and demultiplexing of optical transmission channels, which are modulated up to 100Gbits.
- Passive device without active temperature control (Athermal design).
- Optical connectivity using LC-UPC connectors and 900 micrometer fiber.
- Integrated tap coupler (PLC or fused fiber).

Port Label Description

The following table provides the connection ports, description, and the type of connectors used for each port. All ports are on the module faceplate, which is equipped with optical LC adapters.

The following table describes the port labels and its descriptions for the PTP filter module.

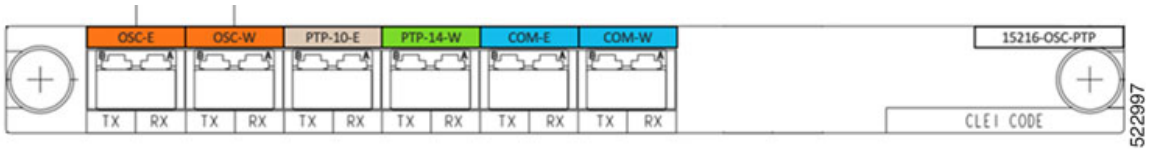
Table 9: Port Label Description

Port	Color	Direction	Type of Connector	Description
OSC-E	Orange	TX	LC-UPC II	Optical Service Channel output to East Direction
		RX		Optical Service Channel input from East Direction
OSC-W	Orange	TX	LC-UPC II	Optical Service Channel output to West Direction
		RX		Optical Service Channel input from West Direction
PTP-10-E	Beige	TX	LC-UPC II	Precision Time Protocol output to East Direction
		RX		Precision Time Protocol input from East Direction
PTP-14-W	Lime Green	TX	LC-UPC II	Precision Time Protocol output to West Direction
		RX		Precision Time Protocol input from West Direction
COM-E	Cyan	TX	LC-UPC II	Common output to East Direction
		RX		Common input from East Direction
COM-W	Cyan	TX	LC-UPC II	Common output to West Direction
		RX		Common input from West Direction

Port Identification Label

The port identification label provides port identification of the Cisco 15216-OSC-PTP Filter module. The port label is placed on the faceplate of the Cisco 15216-OSC-PTP Filter module.

Figure 8: Cisco 15216-OSC-PTP Filter Module Label



Optical Specifications

The following table provides the optical specifications of the Cisco 15216-OSC-PTP Filter module.

Table 10: Optical Specifications

Parameter	Minimum	Maximum	Unit	Note
Operating Temperature Range	–5	70	ºC	—
Storage Temperature Range	–40	85	ºC	non-condensing
Operating Humidity Range	5	95	%RH	—
Power Handling	500		mW	Any port
Wavelength Range COM-paths	1500	1520	nm	—
Passband	+/– 1	—	nm	see Figure 6: 15216-OSC-PTP Filter Module Optical Block Diagram, on page 12.
PDL	—	0.2	dB	—
PMD	—	0.1	ps	—
Chromatic Dispersion ADD/DROP path	—	± 10	ps/nm	any optical path
Group Delay Ripple	—	5	ps	peak to peak ripple
Return Loss	45	—	dB	Any port
Directivity	50	—	dB	Any path

The following table provides the optical path specification for each path in the ONS-15216-OSC-PTP Filter module.

Table 11: Optical Path Specifications

Parameter	Condition	Minimum	Maximum	Unit

Isolation Transmission path	—	>30	—	dB
Isolation Reflection path	—	>13	—	dB
OSC-W-RX to COM-W-TX	at 1518 nm	—	<0.3	dB
COM-W-RX to OSC-W-TX	at 1518 nm	—	<1.3	dB
PTP-14-W-RX to COM-W-RX	at 1514 nm	—	<1.0	dB
COM-W-RX to PTP-14-W-TX	at 1510 nm	—	<0.8	dB
OSC-E-RX to COM-E-TX	at 1518 nm	—	<1.3	dB
COM-E-RX to OSC-E-TX	at 1518 nm	—	<0.3	dB
PTP-10-E-RX to COM-E-TX	at 1510 nm	—	<1.0	dB

Safety Information

Before you install, operate, or service this product, you must read the Regulatory Compliance and Safety Information for Cisco Optical Transport Products document for important safety information and warning translations.

This product is compliant with the GR 1089, UL60950 /CSA 22.2 No. 60950-00, and IEC 60950 standards.

Laser Radiation Emission Restrictions

The Class 1M Laser safety and warning label is affixed to this product and indicates that the product should never be used or installed in an optical network with emissions higher than Class 1M.

Warning Class 1M laser radiation when open. Do not view directly with optical instruments. Statement 281

Warning Invisible laser radiation may be emitted from disconnected fibers or connectors. Do not stare into beams or view directly with optical instruments. Statement 1051

Laser Safety During Operation

Warning Invisible laser radiation may be emitted from disconnected fibers or connectors. Do not stare into beams or view directly with optical instruments. Statement 1051

Electrical Safety

This product is optically and electrically passive and requires no electrical connections. No electrostatic discharge (ESD) or other electrical safety considerations apply.